Archives of Neurology and Psychiatry

VOLUME 51 MARCH 1944 NUMBER 3

COPYRIGHT, 1944, BY THE AMERICAN MEDICAL ASSOCIATION

THE HUMAN PYRAMIDAL TRACT

IX. EFFECT OF PARALYSIS PRODUCED BY CEREBRAL TUMORS ON AXONS OF THE PYRAMIDS

A. M. LASSEK, M.D., PH.D.
CHARLESTON, S. C.

The many investigators of the human pyramidal system have been handicapped in not being able either to produce experimentally or to obtain from autopsy material a pure lesion of the corticospinal tract. Until such an isolated lesion can be studied, it is difficult to evaluate what the exact role of this bundle may be in man. Many of the lesions affecting the corticospinal tract occur high up in the central nervous system, in the region of complex, and as yet largely unknown, structures. It seemed possible that, irrespective of the etiologic and pathologic factors, the pyramidal axons might not be completely destroyed in all cases of unilateral paralysis, whether the latter is called hemiplegia or hemiparesis or sometahing else. How many axons, if any, must be missing in the pyramid to produce muscular dysfunction or the abnormal Babinski sign I have not found stated in the literature. With these considerations in mind it was decided to study the effect of paralysis produced by cerebral tumors on the fiber components of the pyramids, a silver stain for the axons serving as a criterion of fiber loss.

MATERIAL AND METHODS

This investigation would not have been possible except for the cooperation of Dr. Joseph Globus, of Mount Sinai Hospital; Dr. Abner Wolf, of the Neurological Institute, and Dr. Charles Davison, of Montefiore Hospital, all of New York. All the clinical information and pathologic diagnoses were obtained from reports in the neuropathologic departments of these institutions.

Of 119 cases in which the medulla oblongata was suitable for study, selected from about 2,000 cases of disease of the brain and cord, 60 were from Mount Sinai Hospital, 49 from the Neurological Institute and 10 from Montefiore Hospital. Only cases were chosen in which there was exhibited one or more of the classic signs of involvement of the pyramidal tract, especially the Babinski sign. Thus, in 100 cases the Babinski sign was present; in 4 cases, the Hoffmann sign, and in 2 cases, the Chaddock sign; in 13 cases no mention of the presence of any of these abnormal reflexes was made. In 34 cases combinations of signs were mentioned, such as the Babinski and Chaddock signs or the Babinski, Oppenheim and Hoffmann signs. In 62 cases the abdominal reflexes were absent on the affected side. In 79 cases the patients were males and in 38 females; in 2 the sex was not mentioned. The average age was 47.7 years. The mean duration of symptoms was six months, with a variation from nine days to three and a half years. In many cases operation was performed shortly after a diagnosis of cerebral tumor was made.

The terms used by the clinicians in diagnosis of the paralyses in this series were as follows: hemiplegia, in 35 cases; hemiparesis, in 34 cases; muscular weakness, in 10 cases; complete unilateral paralysis, in 6 cases; pyramidal tract signs, in 5 cases; dragging foot, in 5 cases; difficulty in walking, in 4 cases; falling, in 4 cases; staggering, in 2 cases; heaviness of extremities, in 1 case; inability to move extremities, in 1 case; inability to walk, in 1 case; progressive motor impairment, in 1 case; contracture with paralysis, in 1 case; involvement of a lower limb, in 1 case; flaccid paralysis, in 1 case, and aphasia with vesical and rectal disturbance, in 1 case. In 5 cases the diagnosis was not recorded. In 90 cases the cerebral tumor was primary; in 12 cases the tumor was a meningioma, and in 17 cases it was a secondary carcinoma. The large majority of the primary tumors were of the following types: glioblastoma multiforme, glioblastoma, spongioblastoma and astrocytoma.

The lesions involved all parts of the cerebrum. Of the 119 cases, a single lobe was affected in 47, a combination of lobes in 51, the subcortical tissue alone in 17, the floor of the skull in 1 and both hemispheres in 1; in 2 cases the pathologic process was questionable. The frontal lobe was involved alone in 15 cases, the temporal lobe in 16, the parietal lobe in 13 and the occipital lobe in 3. Two lobes were affected in 37 cases, three lobes in 13 and four lobes in 1. Alone or in combination the frontal lobe was involved in 47, the parietal lobe in 48, the temporal lobe in 40 and the occipital lobe in 24. According to the neuropathologic reports, no involvement of the frontal lobe, the seat of the so-called motor cortex, was apparent in 72 cases.

All of the brains from which the medullas were obtained had been kept in jars containing a dilute solution of formaldehyde U. S. P., the time of fixation varying from a few days to sixteen years. Subsequently, cross sections of all the medullas were stained by Davenport's original silver nitrate method after fixation in the solution of formaldehyde, a method which is specific for axons.[1] This technic gave rather uniform results in spite of the variations in time of fixation. The possibility that glial fibers were stained was ruled out.

The amount of damage to the specimens which showed obvious loss of pyramidal fibers was determined by measuring the square areas of the abnormal and the normal sides, sampling the tract with a Whipple square and then computing the loss.

This study was aided by a grant from the Committee on Scientific Research of the American Medical Association.

From the Department of Anatomy, Medical College of the State of South Carolina, and the Department of Neurology, Columbia University College of Physicians and Surgeons, New York.

1. Davenport, H. A.: Staining Nerve Fibers in Mounted Sections with Alcoholic Silver Nitrate Solution, Arch. Neurol. & Psychiat. **24**:690-695 (Oct.) 1930.

RESULTS

In only 17 (14.3 per cent) of the 119 cases was there observable evidence of destruction of the pyramidal tract. In 14 of these the patients were males, and in all 17 the average age was 43.4 years. In 9 (7.6 per cent) partial and in 8 (6.7 per cent) complete destruction was observed.

Either by coincidence or by predilection, all the patients who exhibited complete loss of pyramidal fibers were males. In this group the average age was 39.4 years. Absence of the superficial abdominal reflexes was recorded in 4 cases of these 8 cases, the Babinski sign was present in 6 cases and the Hoffmann sign in 1 case, and the presence of pyramidal tract signs was mentioned in 1 case. The clinical diagnoses were as follows: weakness, 1 case; complete hemiplegia, 3 cases; complete hemiparesis, 1 case; paralysis, 1 case; complete paralysis, 1 case, and contracture with paralysis, 1 case. The lesions were widespread; more than one lobe was always involved, including the frontal lobe and usually subcortical elements.

The estimated amounts of axonal loss in the 9 partially damaged pyramids were as follows: 5, 25, 40, 50, 50, 50, 75, 75 and 80 per cent. The lesions in these cases likewise were rather widespread, and in only 1 case was one lobe of the brain alone involved, in this instance the parietal. The pyramidal tract in this case showed damage to about 50 per cent of the fibers. In most cases the frontal lobe and subcortical structures were invaded. In this series of cases, 5 patients were males and 3 females, and the sex of 1 was not mentioned. In 6 cases the sign of Babinski was present; in 1 case pyramidal tract signs were recorded, and in 2 cases the evidence was questionable. In 4 cases the diagnosis was hemiplegia; in 2 cases, hemiparesis; in 1 case, pyramidal tract signs; in 1 case, weakness, and in 1 case, paralysis. In none of the cases of partial damage to the pyramidal tracts were isolated or restricted parts of the pyramids affected; degeneration was scattered and uniformly distributed.

In the other 102 cases, I was unable to detect any loss of fibers, gliosis or decrease in area in the pyramids. To be fair, when one is counting so many axons and using a silver stain, one might miss some less easily detected fibers. A Marchi stain, for instance, might show the presence of degenerated fibers. It appeared, however, that the individual damage in these cases was minimal, or possibly absent. The pathologic reflexes observed in this series of 102 cases were as follows: the Babinski sign, in 88 cases; the Hoffmann sign, in 3 cases, and the Chaddock sign, in 2 cases; in 9 cases there was no record of abnormal reflexes. There were also combinations of these signs. In 28 of the cases the condition was diagnosed as hemiplegia, in 31 as hemiparesis, in 8 as weakness and in 5 as complete unilateral paralysis; in 28 cases it was designated by a less specific term. In 66 cases the patients were males and in 38 females, and in 1 case the sex was not reported. Practically every part of the cerebrum was affected; in one third of the cases the frontal lobe was involved. Since often individual gyri of the brain were not named with respect to the extent of the tumor, I cannot say how often the precentral convolution was injured.

COMMENT

On the basis of the material and methods utilized in this investigation, it appears that motor deficit in man, with one or more of the classic signs of damage to the pyramidal tract, can be produced with little or no loss of the axis cylinders in the pyramid. Of this series of 119 selected cases of tumor of the cerebrum, complete axonal loss was shown in 6.7 per cent and partial destruction in 7.6 per cent, and in 85.7 per cent there was no observable change. In the last group it is possible that loss of some fibers could not be detected with the silver stain alone, but such loss must have been minimal.

Various terms were used by the clinicians to describe motor deficit in these cases, and it is difficult to correlate them with destruction of the pyramidal tract. For instance, the terms "weakness" and "hemiparesis" were employed to indicate the amount of motor deficit in 2 cases in which microscopic examination showed complete destruction of the axons in the pyramid. In all, seventeen expressions were used to describe muscular dysfunction. It would be no easy task to standardize the terminology so that one term would accurately express a certain degree of paralysis. Since the physiologic motor deficits were studied by a number of clinical observers, it is possible that some of them did not have in mind disease of the pyramidal tracts. The individual terms employed would have meaning only for the examining neurologist and could not be evaluated correctly by another person, least of all by one not connected with the hospital. It should be mentioned, also, that in some instances the records of the history and the physical examination were not as complete as one might desire. In some instances the Babinski sign was evidently elicited only once without further recorded trials; so there is a chance that in some cases this sign may have been transient. It can be said, however, that in general the cere-

bral tumors in this series of cases caused motor dysfunction severe enough to result in incapacitation. The cases were carefully selected from about 2,000 cases of disease of the brain and cord, and I believe they represent the least equivocal specimens that can be obtained from available stored material. The criteria primarily used for selection of the cases were the classic signs of damage to the pyramidal tract, especially the Babinski sign, rather than the diagnoses made by the clinicians. It is realized that the ideal situation would be one in which a single skilled investigator followed suitable cases from beginning to end, and it is hoped that this may eventually be done.

In this series, a tumor mass in any part of the cerebrum apparently produced motor deficit with either a transient or a permanent Babinski sign. In many cases the frontal lobe was not involved. If these observations are correct, it should be difficult to localize tumors on the basis of so-called pyramidal tract signs alone. In order that the axons of the pyramidal bundle may be completely destroyed, rather widespread involvement of the brain appears necessary, and in almost all cases subcortical structures were implicated. Von Monakow [2] observed that in man destruction of a whole hemisphere seems necessary for destruction of all the fibers of the pyramidal tract. The recent experimental investigations of Häggqvist; Hoff and Hoff; Kennard; Lassek; Lassek and Rasmussen; Minckler and Klemme; Peele, and Spiegel, Weston and Oppenheimer [3] have indicated that the origin of the pyramidal tract may involve more than area 4. If these current observations are correct, more extensive damage to the cortex would be expected to cause complete destruction of the pyramidal tract.

In cases of cerebral tumor it is well known that the intracranial pressure is increased and that there may be interference with the blood supply. If increased cerebrospinal pressure is a factor, it is difficult to see why or how it should single out the pyramidal tract alone and leave unaffected axons belonging to other systems. It is unlikely that increased pressure would cause death of the neurons. The part it plays, if any, might be one of depression of nerve activity. On the other hand, if there is interference with the vascular supply to the so-called motor cortex due to lesions remote from this area, it is probable that death of the neuron might occur in cases of chronic disturbance in the blood supply. These suggestions, however, are mere speculations.

There is evidence that paralysis and the sign of Babinski may occur in many cases with little or no destruction of pyramidal axons. Since the stain employed is selective for axis-cylinders, I am unable to state, at this stage, whether a technic for myelin sheaths would confirm the present observations. Further studies on this phase, with stains for myelin sheaths and fats, are in progress in this laboratory. One should keep in mind, perhaps, that in some of these cases the cells of origin of the pyramidal tract, or the fibers arising from them, may be temporarily deprived of function by pressure, anoxemia, narcotic poisoning or some other phenomenon. These factors might be suggested to explain a transient Babinski sign. I wish to be conservative and cautious in advancing any radical opinion concerning the pyramidal system.

CONCLUSIONS

Within the limits of the materials and methods used in the present investigation, there is some foundation for the following conclusion: In cases of cerebral tumor, unilateral motor deficit, with one or more pyramidal tract signs, may occur with little or no loss of axons in the pyramidal tract. In 8, or 6.7 per cent, of 119 cases was destruction complete. Apparently, tumors located in any part of the cerebrum may produce motor difficulties with signs of damage to the pyramidal tract. In this series the tumors which caused complete destruction were widespread. It is difficult to correlate the terminology employed in describing paralyses with the destruction of the pyramidal tract.

2. von Monakow, C.: Zur Anatomie und Physiologie der Pyramidenbahn und der Armregion nebst Bemerkungen über die sekundäre Degeneration des Fasciculus centroparietalis, Neurol. Centralbl. **34**:217-224, 1915.

3. Häggqvist, G.: Faseranalytische Studien über die Pyramidenbahn, Acta psychiat. et neurol. **12**:457-466, 1937. Hoff, E. C., and Hoff, H. E.: Spinal Terminations of the Projection Fibers from the Motor Cortex in Primates, Brain **57**:454-474, 1934. Kennard, M. A.: Corticospinal Fibers Arising in the Premotor Area of the Monkey, Arch. Neurol. & Psychiat. **33**:698-711 (April) 1935. Lassek, A. M.: The Pyramidal Tract: The Effect of Pre- and Postcentral Lesions on the Fiber Components of the Pyramids in the Monkey, J. Nerv. & Ment. Dis. **95**:721-729, 1942. Lassek, A. M., and Rasmussen, G. L.: The Human Pyramidal Tract: A Fiber and Numerical Analysis, Arch. Neurol. & Psychiat. **42**:872-876 (Nov.) 1939. Minckler, J., and Klemme, R. M.: Role of the Premotor Cortex in Human Motor Activity, Proc. Soc. Exper. Biol. & Med. **53**:264-265, 1943. Peele, T. L.: Cytoarchitecture of Individual Parietal Areas in Monkey (Macaca Mulatta) and the Distribution of Efferent Fibers, J. Comp. Neurol. **77**:693-723, 1942. Spiegel, E. A.; Weston, K., and Oppenheimer, M. J.: Postmotor Foci Influencing the Gastrointestinal Tract and Their Descending Pathways, J. Neuropath. & Exper. Neurol. **2**:45-53, 1943.

PATHOLOGIC FEATURES OF HERPES ZOSTER

A NOTE ON "GENICULATE HERPES"

D. DENNY-BROWN, M.B., AND RAYMOND D. ADAMS, M.D.
BOSTON
AND
LIEUTENANT (JG) PATRICK J. FITZGERALD (MC), U.S.N.R.

Herpes zoster, or zona, is a common nervous disease known since ancient times but still possessing many enigmatic features. From the contributions of von Bärensprung,[1] Head and Campbell,[2] Lhermitte and Nicolas[3] and many others the broad outlines of this condition may be sketched.

The present day conception of herpes zoster embraces the following assumptions and facts: The disease is probably due to a filtrable virus, similar to, if not identical with, that of varicella, which provokes an acute inflammatory reaction in isolated spinal or cranial sensory ganglia, the posterior gray matter of the spinal cord and the adjacent leptomeninges. The clinical manifestations are a vesicular cutaneous eruption, radicular neuralgia and, less often, segmental palsies and sensory loss.

The association of the cutaneous eruption with a disease of the peripheral nerves was brilliantly deduced from clinical data by von Bärensprung [1a] in 1861, and in 1862 he described in considerable detail the inflammatory changes in a dorsal root ganglion and related portions of the spinal nerve in a case in which autopsy was performed (von Bärensprung [1b]). Head and Campbell [2] indicated the necrotic and limited character of the ganglionic lesions and the patchy inflammation of the neighboring ganglia. The cause of this ganglionic necrosis and its relation to changes in the neighboring ganglia and nerves, particularly the motor nerve root, are still obscure. For this reason further observations are desirable.

In view of the large number of sensory ganglia which may be involved the clinical possibilities are manifold. In the region of the cranial nerves two special syndromes are frequent, namely, "ophthalmic herpes" and "geniculate herpes." The pathologic changes in the gasserian ganglion in the former syndrome were described by Head and Campbell.[2] The combination of paralysis of the facial nerve and auricular herpes, with or without deafness, tinnitus and vertigo, was first ascribed to a herpetic lesion of the geniculate ganglion by Ramsay Hunt.[4] In the many papers which Hunt wrote on this subject, he described the postmortem changes in only 1 case, and in that the geniculate ganglion was not examined. We have found only one other histologic study of the "geniculate syndrome" in the literature, that of Maybaum and Druss,[5] who reported a case of periarteritis nodosa in which palsy of the face was present three months before death, and pain with blebs on the tympanic membrane, auricle and pinna six weeks before death. The cells of the geniculate ganglion were described as shrunken, pyknotic and, in some instances, disintegrated. The lesion shown in their illustration does not resemble that characteristic of herpes zoster. Our case 3, an instance of "occipitocollaris" and "auricular" herpes with palsy of the facial nerve, a variety of the syndrome recognized by Hunt,[4] is therefore of particular interest.

REPORT OF CASES

CASE 1.—H. T., a man aged 69, was admitted to the National Hospital for Nervous Diseases, Queen Square,

From the Department of Nervous Diseases, Harvard Medical School; the Neurological Unit, Boston City Hospital, and the Mallory Institute of Pathology, Boston City Hospital.

1. von Bärensprung, F. G. F.: (*a*) Die Gürtelkrankheit, Ann. d. Char.-Krankenh. zu Berlin **9**:40-128, 1861; (*b*) Beiträge zur Kenntnis des Zoster, ibid. **10**:96-104, 1862.

2. Head, H., and Campbell, A. W.: The Pathology of Herpes Zoster and Its Bearing on Sensory Localisation, Brain **23**:353-523, 1900.

3. Lhermitte, J., and Nicolas: Les lésions spinales du zona: La myélite zostérienne, Rev. neurol. **1**:361-364, 1924.

4. Hunt, J. R.: (*a*) Herpetic Inflammations of the Geniculate Ganglion: A New Syndrome and Its Complications, J. Nerv. & Ment. Dis. **34**:73, 1907; (*b*) A Further Contribution to the Herpetic Inflammations of the Geniculate Ganglion, Am. J. M. Sc. **136**:226, 1908; The Sensory System of the Facial Nerve and Its Symptomatology, J. Nerv. & Ment. Dis. **36**:321-350, 1909; Herpetic Inflammations of the Geniculate, Auditory, Glossopharyngeal and Pneumogastric Ganglia, Arch. Int. Med. **5**:631 (June) 1910.

5. Maybaum, J. L., and Druss, J. G.: Geniculate Ganglionitis (Hunt's Syndrome): Clinical Features and Histopathology, Arch. Otolaryng. **19**:574-581 (May) 1934.

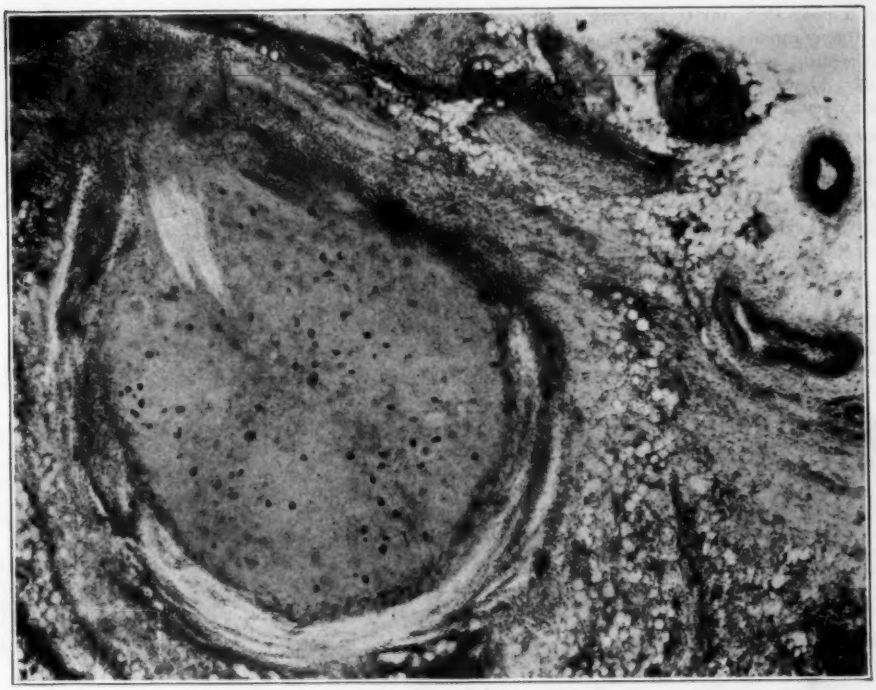


Fig. 1 (case 1).—Fifth dorsal root ganglion; Nissl stain. The capsule and periganglionic fat are infiltrated. The ganglion cells are visible only as pale "ghosts" in the necrotic area. The pigment of other cells remains as dark masses. In the right upper corner three small arteries are seen in section. The uppermost artery is occluded by an organized thrombus. The adventitia of the other arteries shows cellular reaction.

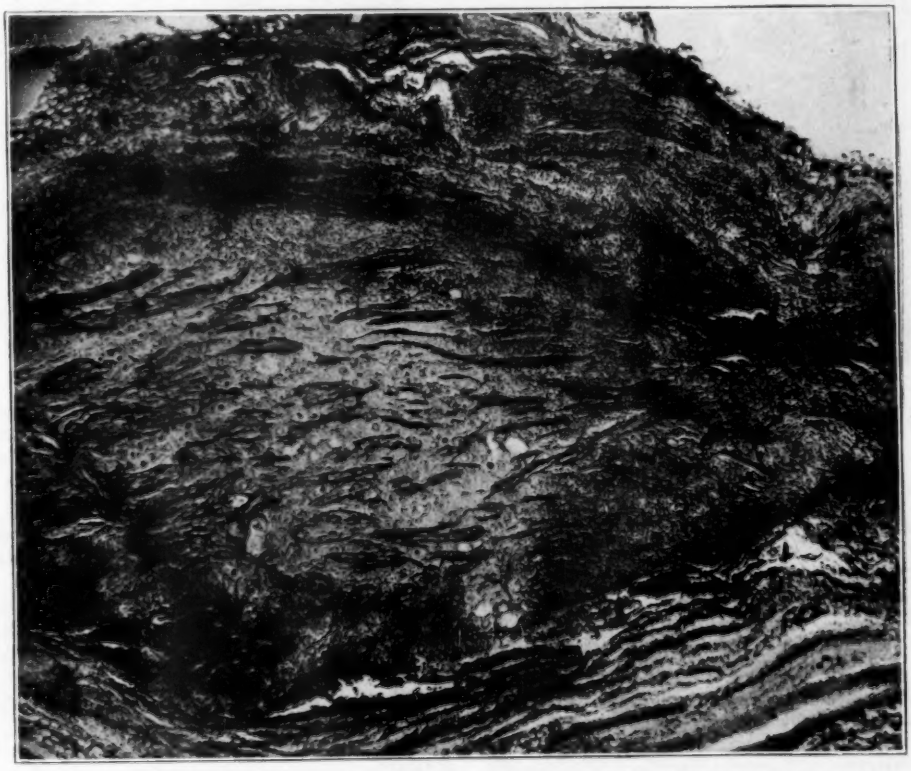


Fig. 2 (case 2).—Second cervical root ganglion; Bielschowsky method, counterstained with cresyl violet. Streaks of argentophil necrotic nerve fiber bundles cross the area of necrosis, where "ghost" cells and pigment are the sole remnants of the ganglion cells. The capsule and the peripheral parts of the ganglia are involved in a dense inflammatory reaction. Two arterioles are seen at the upper margin.

London, in September 1931, under the care of Dr. Hinds Howell, with the complaint of constant epigastric discomfort and shooting pains in the lower limbs of one year's duration. There had been deterioration of intellectual faculties over a similar period.

Examination.—He was talkative and emotional. Memory was defective. The pupils were small and fixed to light. Slight ptosis of the eyelids and some tremor of the tongue were noted. No defect in muscular power or in coordination was observed. The ankle jerks could not be obtained, but the knee and arm jerks were present and equal on the two sides. There were patchy areas of hypalgesia over the face and limbs and diminution of deep pain sensation in the achilles tendon and the testes. Sense of vibration was diminished in the lower limbs. On October 1 lumbar puncture revealed that the cerebrospinal fluid was under a pressure of 60 mm.; examination of the fluid revealed 26 lymphocytes per cubic millimeter, a total protein content of 55 mg. per hundred cubic centimeters, a weakly positive reaction for globulin, a colloidal gold curve of 4555555542 and a strongly positive Wassermann reaction. The Wassermann reaction of the blood was also strongly positive.

Course of Illness.—The patient was given mercury by inunction and iodides by mouth. Small elevations of temperature were induced on three occasions by the intravenous injection of bacterial vaccine made from the typhoid bacillus and the paratyphoid "A" and "B" bacilli U. S. P. A course of neoarsphenamine was also instituted, and the patient received 0.45, 0.45, 0.6 and 0.6 Gm. respectively at intervals of a week. On November 30, a few days after the last injection of the arsenical, a profuse hemorrhagic herpes zoster was found covering the region of the fifth and sixth dorsal cutaneous segments on the left side. No pain was associated with the eruption. A few days later there developed fever and obvious pneumonia, of which the patient died on December 11 (eleven days after the appearance of the eruption).

Anatomic Diagnosis.—The diagnoses were dementia paralytica and tabes dorsalis; herpes zoster, with inflammation of the fifth dorsal root ganglion on the left side, and terminal pneumonia.

Postmortem Examination (Dr. J. G. Greenfield).—Autopsy revealed pneumonia in the base on the left lung; edema of both lungs; notable cerebral atrophy, with much fluid in the meningeal spaces; some hemorrhagic fluid around the brain stem, and milky thickening of the spinal meninges. The cerebral meninges were slightly thickened. There was slight granular ependymitis.

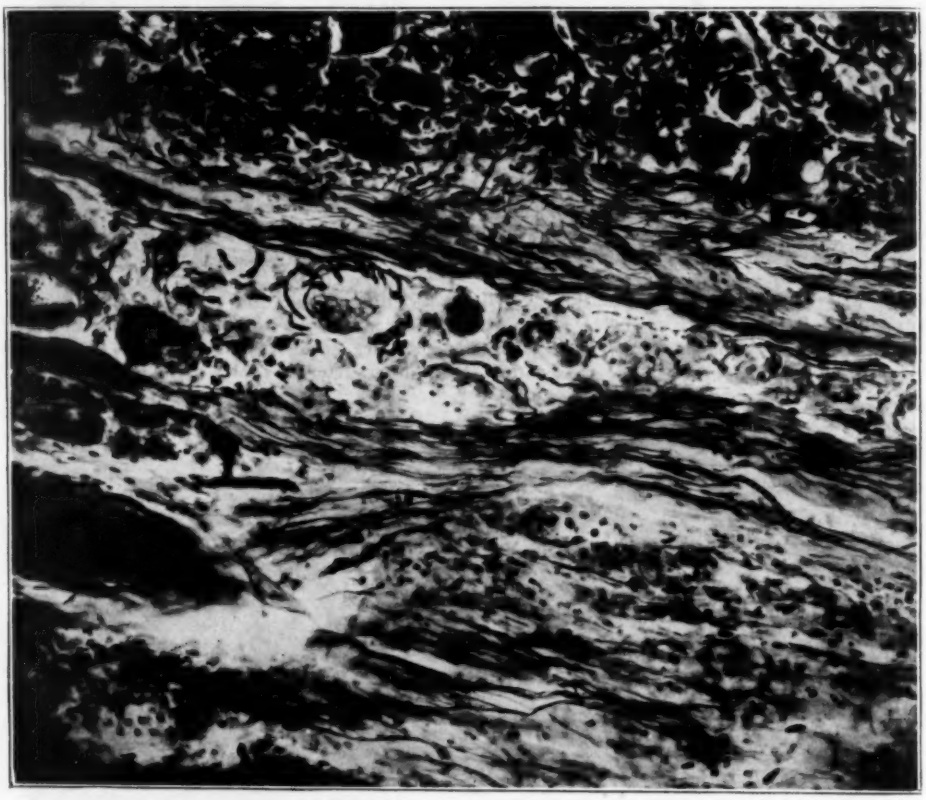


Fig. 3 (case 1).—Fifth dorsal root ganglion; Gros-Bielschowsky method. Remnants of ganglion cells, one of which is vacuolated, with subcapsular whorls, and fine axis-cylinder fibrils at the margin of the necrotic area are shown. Dense lymphocytic infiltration is seen above. Below, and to the right, axis-cylinders extending into the necrotic zone end in knobs and clubs.

Through the permission of Dr. J. G. Greenfield and Dr. Hinds Howell, one of us (Denny-Brown) was enabled to remove and examine the fifth dorsal root ganglion and the dorsal primary division of the fifth dorsal spinal nerve on the left side and a portion of the skin involved in the eruption.

Microscopic Examination.—Skin: There was considerable lymphocytic infiltration of the dermis and of the subcutaneous nerve branches under a vesicle.

Brain: The microglia of the cortex showed great overgrowth, with slight and scattered perivascular infiltration. There was loss of nerve cells in the frontal

cortex, with deposition of iron around the vessels and smaller amounts in the microglia. The spinal cord showed slight loss of myelin in the dorsal columns. This picture was consistent with the presence of dementia paralytica with slight tabetic changes.

Dorsal Primary Division of Intercostal Nerve Root: All parts of the nerve examined were infiltrated with lymphocytes and occasional plasma cells. There was complete degeneration of the axis-cylinders.

Fifth Dorsal Root Ganglion: The central portion of the dorsal root ganglion had undergone hemorrhagic necrosis. Normal ganglion cells were to be seen only in a narrow layer under the posterior aspect of the capsule of this ganglion. In many sections no stainable ganglion cells remained (fig. 1). The necrotic area was surrounded by a zone of inflammation, in which lymphocytes, plasma cells and a few polymorphonuclear leukocytes were densely packed (fig. 1). In the inner margin of this zone many degenerate forms were seen (fig. 3). Within this zone of infiltration the ghosts of ganglion cells were recognized by their pigment and faintly stained cytoplasmic outline. There was no recognizable capsule or satellite cells, and cellular interstitial elements were absent. In the inflammatory zone some ganglion cells showed shrinkage of the cell body and proliferation of subcapsular dendrites (fig. 3). In sections in which a margin of ganglion cells was stained by Nissl's method and by silver impregnation large clubs with a whorl of surrounding fibrils frequently occupied the capsule and vacuolated ganglion cells were evident (fig. 3). There had been hemorrhage into the necrotic area, and scattered lymphocytes and plasma cells permeated the sheath of the ganglion. The periganglionic fat also showed patchy inflammatory change. The largest artery and vein accompanying the spinal nerve were undamaged, but a small branch passing to the ganglion (fig. 1) contained an organized thrombus. In the adventitia of the vessel were many lymphocytes, plasma cells and histiocytes. Several smaller branches of this artery also were thrombosed. All vessels in the sheath of the ganglion were surrounded by lymphocytes.

The spinal nerve distal to the ganglion had many sound axis-cylinders, but the majority of these structures were in process of degeneration (fig. 4). The nerve was very cellular, owing to an increase in Schwann cells, histiocytes and plasma cells. In places small hemorrhages separated the fibers. The perineural sheath was separated from the nerve by a layer of lymphocytes and histiocytes, densely packed in places (fig. 5), and occasional hemorrhage. The gray ramus communicans showed only slight cellular reaction, and its nonmedullated fibers appeared unaffected.

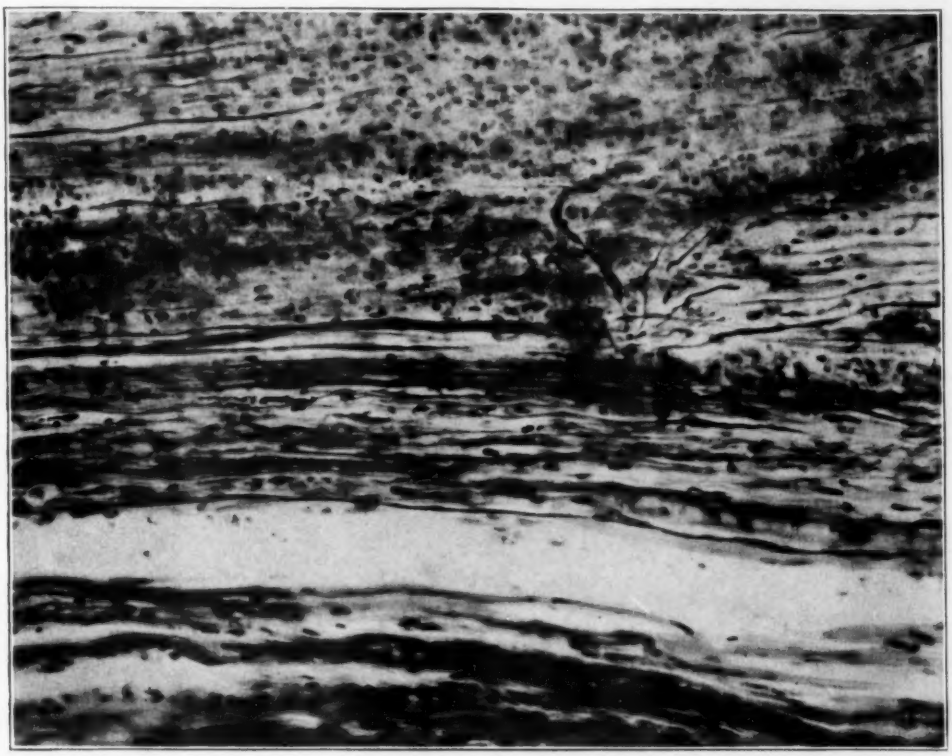


Fig. 4 (case 1).—Peripheral nerve root about 3 cm. distal to the ganglion; Gros-Bielschowsky method, counterstained with cresyl violet. A small hemorrhage, degeneration of many nerve fibers, irregularity of the rest and cellularity of the perineurium (below) are shown.

Dorsal Nerve Root: This portion of the nerve was completely degenerated in all sections. Only sparse argentophil remnants of axis-cylinders remained. The portion nearest the ganglion was completely necrotic, with hemorrhage within the root. More proximally, the root, as it passed through the meninges, was completely surrounded by a dense cuff of cellular exudate (fig. 6*A*).

Ventral Nerve Root: There were many intact fine axis-cylinders, but in Bielschowsky preparations all the larger ones were either beaded or represented by chains of fragments (fig 6*B* and *C*). Degeneration was more commonly encountered distally, where the root joined the peripheral portion of the nerve. The

sheath of the motor root as it passed the ganglion showed little cellular reaction.

Spinal Cord: In the gray matter of the fifth dorsal segment on the side of the affected ganglion the microglia was increased in both the posterior and the anterior horn, particularly in the region of Clarke's column. There was no cuffing of vessels. Some of the sensory nerve cells were replaced by clusters of microglia cells. An occasional anterior horn cell was in the process of phagocytosis (fig. 12 *C*), and others showed clumping Nissl substance in coarse granules around the periphery of the cell. No inclusion bodies were seen.

Case 2.—*History.*—A man aged 74 attended the neurologic outpatient department of the Boston City Hospital because of a painful eruption over the left side of the chest, posteriorly and laterally. This was diagnosed as shingles and treated with an antiseptic powder. The eruption cleared up during the next few days, but the pain continued.

Twenty-two days after the appearance of the eruption severe headache suddenly developed, and the patient became stuporous. He was taken immediately to the hospital, where examination disclosed a comatose condition with left flaccid hemiplegia. The blood pressure was 230 systolic and 140 diastolic. There were dry crusted lesions over the fifth or the sixth thoracic dermatome on the left side. The patient died the following day, twenty-three days after the first appearance of the herpetic eruption.

Anatomic Diagnoses.—The diagnosis was (1) cerebral hemorrhage and (2) herpes zoster with myelitis and ganglionitis (?) involving the sixth dorsal root ganglion on the left side.

Gross Examination.—There was massive hemorrhage in the basal ganglia of the right cerebral hemisphere. The sixth thoracic dorsal root ganglion on the left side was replaced by a cystlike cavity. The adjacent ganglia and the spinal cord were not remarkable.

Microscopic Examination.—Serial sections of the sixth thoracic dorsal root ganglion disclosed only the aforementioned cavity, surrounded by fibrous connective tissue. Neither inflammatory reaction nor hemorrhage suggested that this lesion was in any way related to the recent herpetic infection. The fifth and seventh ganglia on the left side were normal except for an occasional cluster of lymphocytes and a few empty capsules or capsules containing a few histiocytes. The great majority of dorsal root ganglion cells appeared undamaged. Most of the nerve fibers in the posterior root of the fifth thoracic segment had degenerated and were infiltrated with macrophages. In the leptomeninges and the posterior root there were many lymphocytes.

Fig. 5 (case 1).—Thoracic nerve at the origin of the dorsal primary division; Nissl stain. Clumps of lymphocytes appear among the nerve fibers, in the perineural space and in the epineurium.

In the left posterior horn of the gray matter at the fifth thoracic level nerve cells were undergoing destruction, there were large numbers of microglia cells and the small vessels were surrounded by lymphocytes. These changes were observed to a lesser degree in the left anterior horn at the same level but did not cross the midline to the right side. No inclusion bodies were observed in nerve cells of the spinal cord or the dorsal root ganglia.

No microscopic examination was made of the skin or the peripheral nerves.

Case 3.—*History.*—A man aged 62 entered the Boston City Hospital Dec. 9, 1941, with the complaint of a painful rash over the head and neck of eight days' duration. The pain was severe, was limited to the right side of the face, occiput and neck and preceded the eruption by two or three days.

Prior to this illness the patient's health had been fairly good. Approximately ten years before admis-

sion he had a chronic cough and two years before he experienced periodic epigastric pain, which was relieved on institution of the Sippy diet.

Examination.—The temperature, pulse, respiratory rate and blood pressure were normal. The patient was well nourished and well developed; he appeared to be extremely uncomfortable but was not seriously ill. The skin in the right external auditory canal was swollen, red and desquamating. In the right occipital and postauricular regions there was a vesicular eruption, as well as dry, scaling red papules which represented older lesions (fig. 7 *A*). The cervical lymph nodes on the right side were enlarged and tender. The heart and lungs were not remarkable. The spleen was palpable 1.5 cm. below the costal margin. The liver was not palpable. Neurologic examination disclosed no abnormalities at this time.

Laboratory Data.—Examination of the urine showed only the slightest trace of albumin. The red blood cell count revealed 103 per cent hemoglobin, 4,900,000 red cells and 20,750 white cells, of which 75 per cent were polymorphonuclear leukocytes, 18 per cent lymphocytes and 7 per cent monocytes.

The Hinton reaction of the blood was negative. Chemical studies of the blood revealed 30 mg. of nonprotein nitrogen and 5.85 Gm. of total protein per hundred cubic centimeters, with an icteric index of 5.

The stools were formed and brown and gave a positive reaction to the guaiac test. The sputum was negative for tubercle bacilli.

A roentgenogram of the chest revealed minimal fibroid tuberculosis of the apex of the right lung and emphysema.

Course.—On the third day in the hospital (December 12), the eleventh day of his illness, there developed paralysis of the right side of the face, of lower motor neuron type (fig. 7 *B* and *C*), and the tongue deviated to the right. The paralysis was accompanied by a new eruption of vesicles over the posterior aspect of the right side of the head. Hearing was acute. There was impairment of pain and touch sensation over the second and third cervical segments on the right side, the area corresponding to that of the cutaneous eruption. All reflexes were within normal limits.

Examination of the cerebrospinal fluid (December 14) revealed that the pressure was normal; there were

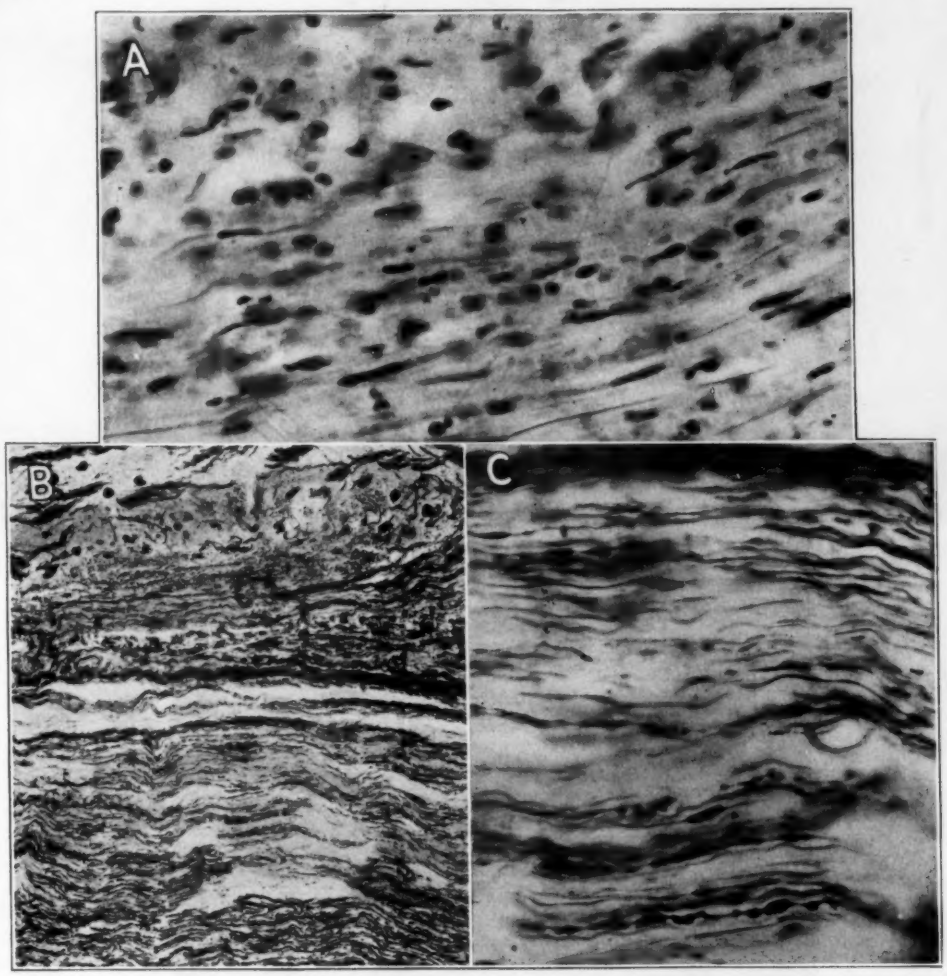


Fig. 6 (case 1).—Fifth dorsal root ganglion; Gros-Bielschowsky method. *A*, part of the meningeal course of the dorsal root, with meningeal reaction (above). *B*, ventral border of the ganglion and its capsule, above, in relation to the motor root, below. *C*, higher magnification of the area of independent degeneration of the ventral root shown in the center of *B*.

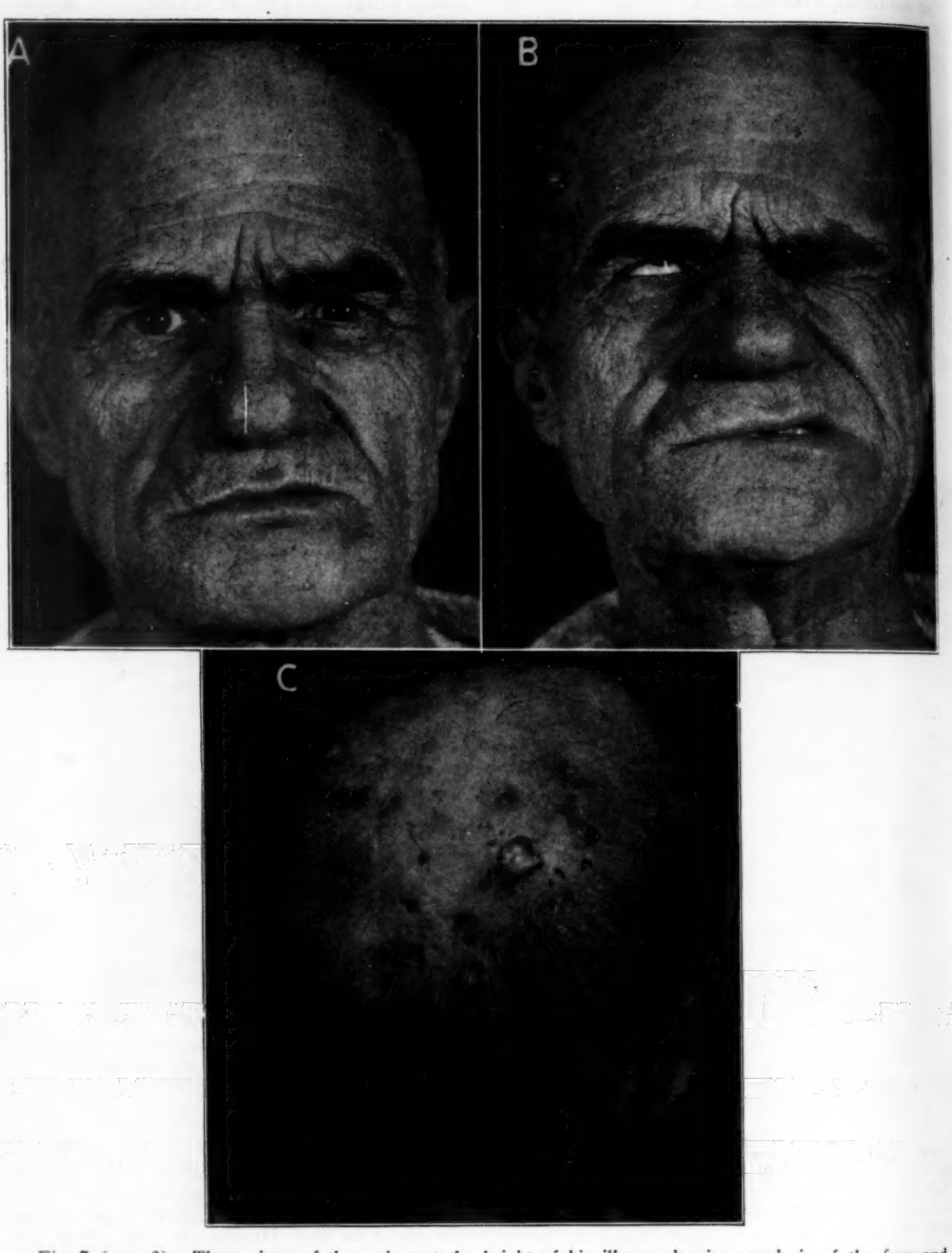


Fig. 7 (case 3).—Three views of the patient at the height of his illness, showing paralysis of the face and healing vesicles over the occiput.

89 lymphocytes per cubic millimeter and 35 mg. of protein, 52 mg. of sugar and 698 mg. of chlorides per hundred cubic centimeters; the colloidal gold reaction was 0112210000, and the Wassermann and Davies-Hinton reactions were negative.

During the next three weeks the facial palsy completely disappeared, and the pain gradually subsided. Most of the vesicles dried up, although on January 21 a small fresh cluster appeared immediately behind the right ear. Hypalgesia remained over the second and third cervical segments. The cell count of the cerebrospinal fluid gradually diminished to 47 lymphocytes per cubic millimeter on the twenty-second day of the illness, to 22 on the thirty-sixth day and, finally, to 15 on the fifty-third day after the onset of the herpes. The patient was discharged from the hospital but was readmitted one week later, on January 31, complaining of intermittent abdominal pain, occurring three or four times a day, usually one hour after meals. On the day of his readmission to the hospital he vomited a large quantity of clotted blood and at about the same time evacuated a large amount of reddish black material from the bowel.

Second Examination.—The temperature was 97 F., the pulse rate 120 and the blood pressure 80 systolic. The patient appeared acutely ill. The skin and the mucous membranes were pale. There were pigmented and crusted lesions over the right side of the head and neck. The abdomen was tender.

Laboratory Data.—The stool gave a positive reaction to the guaiac test. Studies of the blood revealed 68 per cent hemoglobin and 67 mg. of nonprotein nitrogen per hundred cubic centimeters.

Course.—Despite administration of sedatives and 2,000 cc. of whole blood in several small transfusions over a period of three days, the patient continued to vomit and to pass blood by rectum. The blood pressure fell, and he died on the third day in the hospital, or sixty-four days after the onset of herpes zoster, presumably of exsanguination.

Anatomic Diagnoses.—The diagnoses were herpes zoster with ganglionitis (second to third cervical ganglion) and myelitis; hemolytic icterus; peptic ulcer and gastrointestinal hemorrhage, possibly from the ulcer.

Postmortem Examination.—Autopsy was performed two and one-half hours after death. The peritoneal cavity contained 100 cc. of thin, fluid blood. The loops of the small bowel were distended and dark red; the large bowel appeared much darker than usual. There was no evidence of a perforated viscus and no exudate, palpable mesenteric nodes or fat necrosis. The right pleural cavity showed a few thin fibrous adhesions between the apex of the right lung and the anterior wall of the chest. The heart was normal in size, and the coronary arteries were relatively free from sclerosis. There was a firm fibrous scar in the apex of the right lung, but otherwise the lungs were crepitant throughout. The spleen weighed 290 Gm., and the capsule was tense, grayish purple and smooth. The cut surface showed firm, reddish purple tissue, with prominent trabeculations and increased consistence. The splenic artery and vein were patent. The esophagus was without varices or ulcer. A small ulcer, questionably healed, which measured 0.3 to 0.4 cm. in diameter, was observed on the lesser curvature of the stomach about 4 cm. from the pylorus. The ulcer did not extend more than 0.1 cm. into the mucosa, and no visible vessels were present in the base. The small bowel and the colon were filled with dark, fluid blood. The intestinal wall appeared viable, and dissection of the entire vascular system, both arterial and venous, revealed no thrombosis. It was impossible to determine whether the ulcer was the cause of the hemorrhage, but no other source was discovered.

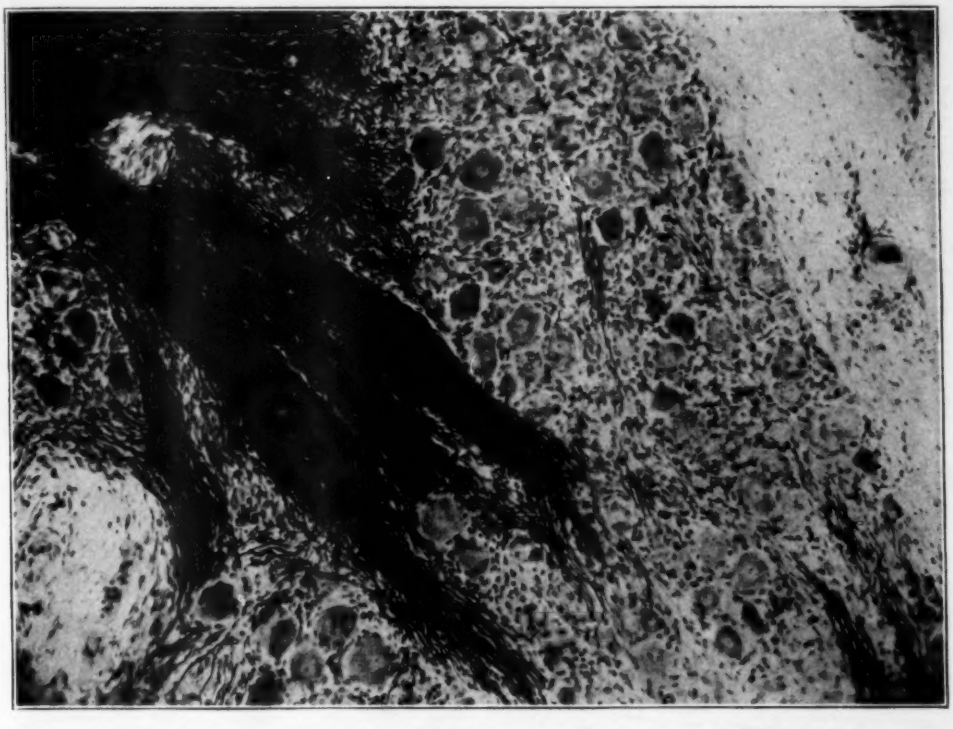


Fig. 8 (case 3).—Geniculate ganglion; Gros-Bielschowsky method, with cresyl violet. Normal ganglion cells and capsules and intraganglionic nerve fibers.

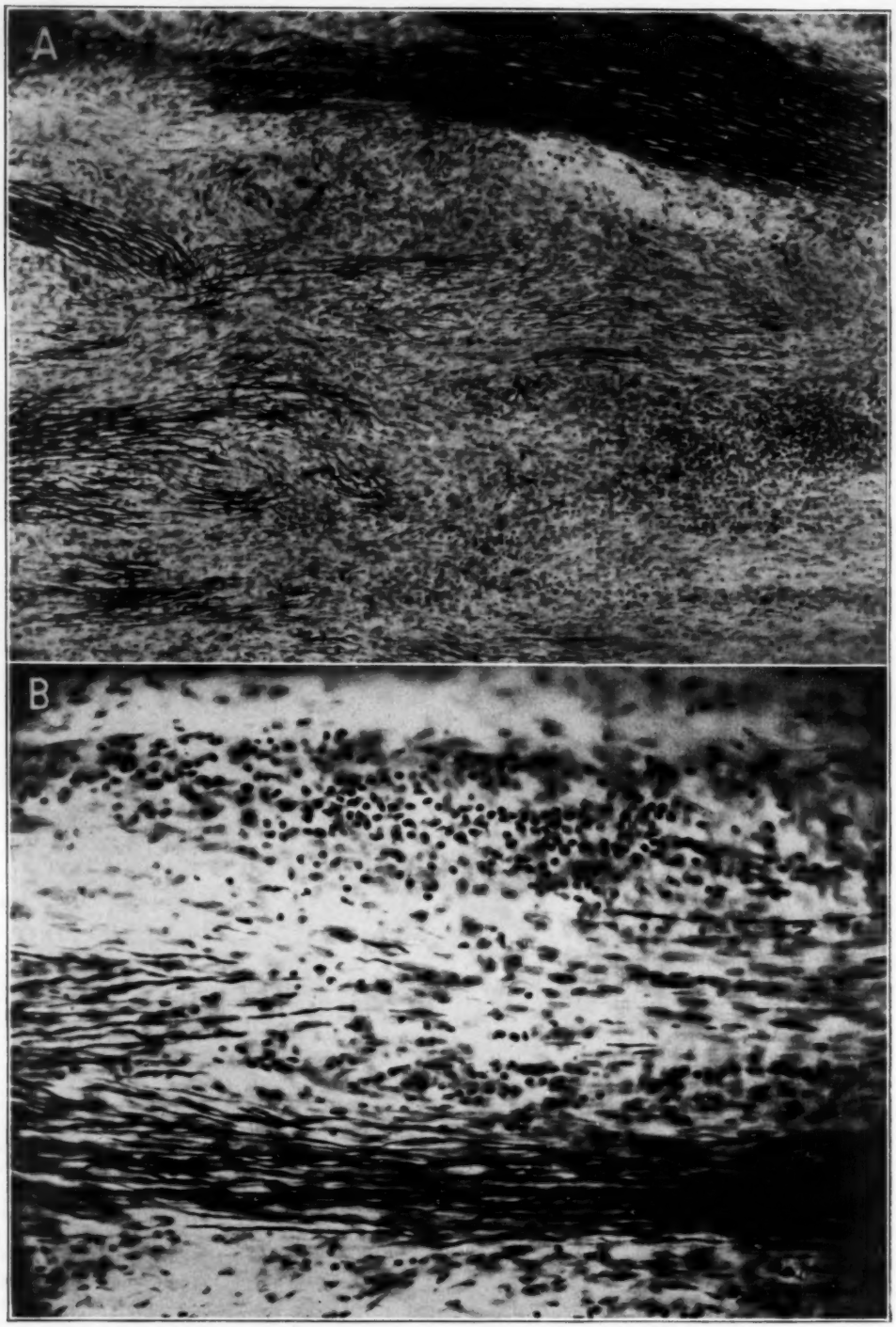


Fig. 9 (case 3).—*A*, focus of degeneration and regeneration, with cellular reaction in the motor fibers of the seventh nerve immediately proximal to the geniculate ganglion; Gros-Bielschowsky method, counterstained with cresyl violet. The sound fibers above are of the pars intermedia. The damaged nerve bundle below skirts the ganglion in its more distal course. *B*, a focus of inflammatory reaction and regeneration of axis-cylinders in the seventh nerve about 5 mm. distal to the ganglion. Note beading of the regenerating fibers, similar to that shown in *A*.

The liver weighed 1,380 Gm. The capsule was smooth and glistening, and the cut surface was finely lobulated and yellow-brown. The gallbladder and biliary system were normal. The kidneys were grossly normal. No lesions were observed in the brain or the spinal cord as examined in the fresh state.

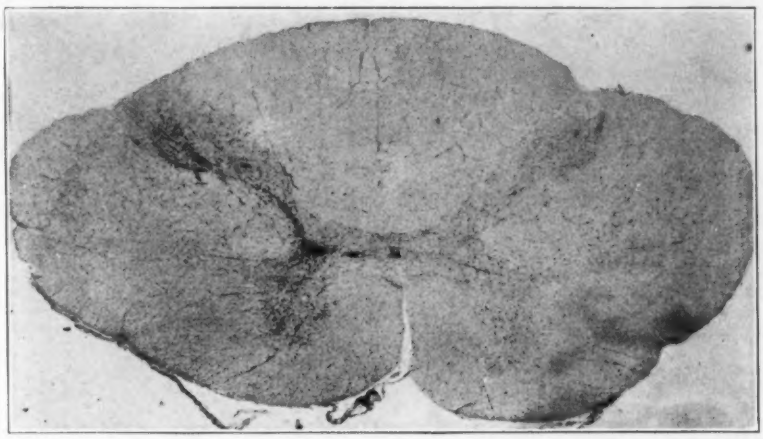


Fig. 10 (case 3).—Second cervical segment of the spinal cord; Nissl stain. Inflammatory reaction in the gray matter on the right side.

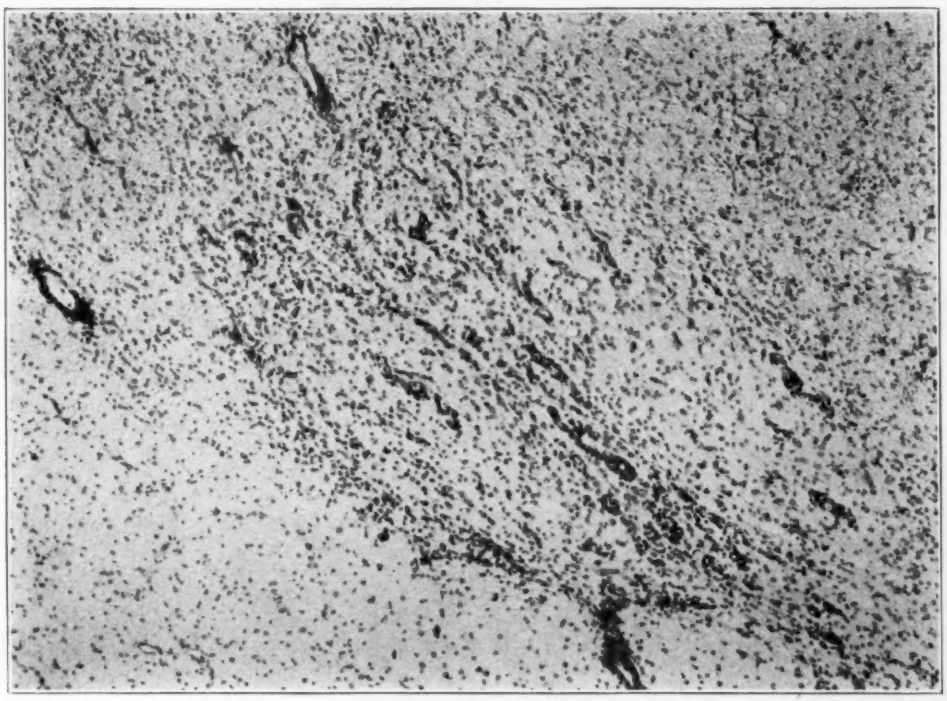


Fig. 11.—Higher magnification of part of the dorsal horn shown in figure 10.

Microscopic Examination.—The heart, esophagus, stomach, duodenum, jejunum, colon, pancreas, liver, adrenals, genitalia, aorta and hilar and aortic lymph nodes were normal. The venous sinuses of the spleen were widely patent and empty of red blood cells, and the endothelial lining cells were thickened. The splenic pulp contained large accumulations of red blood cells.

The brain, spinal cord, sensory ganglia, right geniculate ganglion (which was removed by dissection, together with the seventh nerve, from its meningeal course to just beyond the ganglion) and portions of nerves were stained with hematoxylin and eosin and with cresyl violet and by the Gros silver method for axis-cylinders and the Marchi method for products of myelin degeneration.

Seventh Nerve and Geniculate Ganglion: The geniculate ganglion contained a normal complement of cells, none of which appeared to have suffered any damage (fig. 8). There was no cellular infiltration.

Patchy infiltration with lymphocytes was observed throughout the course of the seventh nerve. In the intracranial portion of the nerve the cellular reaction was scattered and at no point intense. No certain evidence of damage to the nerve fibers was seen at this

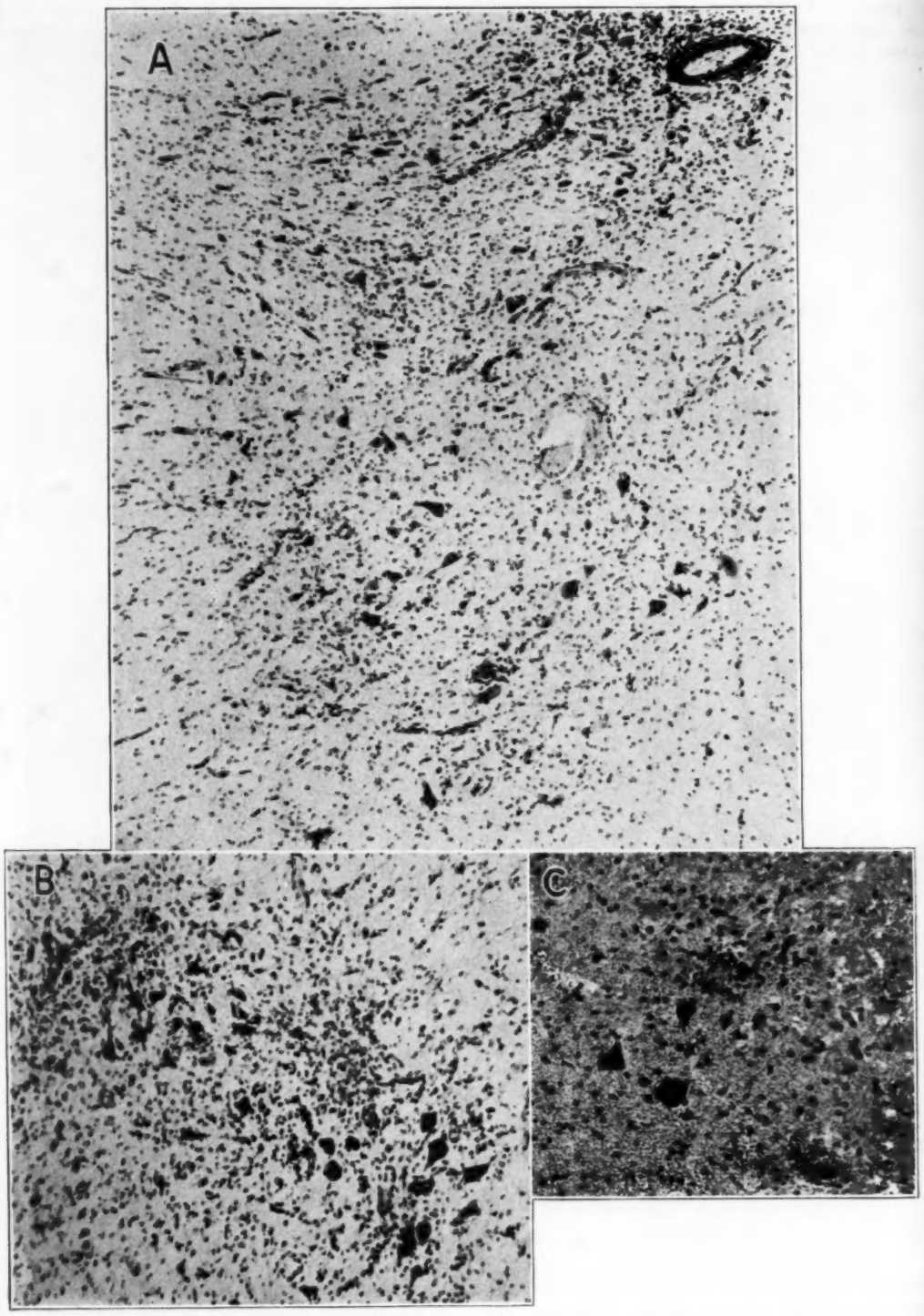


Fig. 12.—*A* (case 3), higher magnification of the ventral horn shown in figure 10, presenting perivascular infiltration in the upper right corner. *B* (case 3), ventral horn at the level of pyramidal decussation. There are proliferation of microglia and destruction of nerve cells. *C* (case 1), ventral horn of the fifth dorsal segment, showing neuronophagia and a small hemorrhage; iron hematoxylin and Van Gieson stain.

level. Immediately within the fallopian canal there was a dense patch of lymphocytic cells, with an occasional plasma cell. Such accumulations appeared at irregular intervals throughout the remainder of the course of the nerve. One focus lay just proximal to the geniculate ganglion (fig. 9*A*) and another immediately distal (fig. 9*B*), both clearly related to bundles of nerve fibers which did not enter the ganglion. The axis-cylinders related to such an accumulation were beaded and thinned, and a few had end bulbs. Nearer the internal auditory meatus an occasional single damaged axis-cylinder was visible.

Dorsal Root Ganglia (right side): Second cervical ganglion: The whole ganglion was virtually destroyed (fig. 2). The central portion was completely necrotic, faint "ghosts" of cell bodies being the only recognizable structures in sections stained with cresyl violet or hematoxylin and eosin. In Bielschowsky preparations necrotic remnants of axis-cylinders had still an argentophil property; these structures were seen as streaks crossing the necrotic zone in figure 2. In the necrotic region there were no viable cells, either interstitial or parenchymatous, nor were there any recognizable blood vessels.

Fig. 13 (case 3).—Spinal cord at the pyramidal decussation, showing degeneration of myelin on the right side; Marchi stain.

The completely necrotic area was surrounded by a wide zone of dense lymphocytic infiltration extending to the capsule of the ganglion, which was also infiltrated. Proximally, the necrosis extended to the region of entry of the dorsal root, the root passing through the zone of lymphocytes as it entered the ganglion. Distally, the necrosis appeared to extend a distance of 1 to 2 mm. into the nerve as it issued from the ganglion. Beyond this cellular zone both the proximal and the distal portion of the dorsal root showed no remnants of axis-cylinders.

The portion of the ventral root which passed under the ganglion was diffusely infiltrated with lymphocytes. In its proximal part were many regenerating axis-cylinders, which became fewer as they were traced distally. In the region of fusion of the ventral and the dorsal root one or two axis-cylinders remained in each section.

The total destruction of the body of the dorsal root ganglion closely resembled infarct necrosis. The large vessels, both arterial and venous, which lay outside the ganglion were of normal appearance. The vessels in the sheath of the ganglion were "cuffed" with lymphocytes and showed endothelial proliferation, but contained red cells. There were no hemorrhages.

Third cervical ganglion: Most of the cells were intact. A few empty capsules and a few small collections of lymphocytes were present.

Fourth cervical ganglion: The ganglion was normal.

Fifth cervical ganglion: The ganglion was normal. The first cervical ganglion was not examined.

Posterior Roots in Their Meningeal Course: The first posterior cervical root was severely degenerated. The second posterior cervical root was completely degenerated, and no normal axis-cylinders could be seen. The root was infiltrated with lymphocytes; Schwann cells were increased in number and size, and histiocytes were abundant. The third, fourth and fifth posterior cervical roots were normal.

Spinal Cord: Level of pyramidal decussation: Here proliferation of microglia was conspicuous on the right side. Perivascular and meningeal infiltrates of lymphocytes were prominent. Many of the motor nerve cells in the supraspinal nucleus of the spinal accessory nerve on the right side were degenerated and surrounded by microglia cells (fig. 12*B*).

First cervical level: Microglial proliferation was present in the posterior horn, with slight lymphocytic infiltration of the meninges. There was little change in the anterior horn at this level.

Second cervical level: There were large numbers of microglia cells in the posterior and anterior horns on the right side, lymphocytes in the perivascular spaces, clumping of Nissl substance in some nerve cells and necrosis and neuronophagia of others (figs. 11 and 12*A*). The Marchi stain revealed degenerated nerve fibers medial to the posterior horn on the right side (fig. 13).

Third cervical level: A slight increase in microglia cells in the right posterior horn was the only alteration at this level.

Fourth and fifth cervical levels: Nothing abnormal was observed.

Brain Stem: Medulla: In the right lateral tegmental region were several small collections of microglial phagocytes. These were located between the spinal nucleus of the trigeminal nerve and the nucleus ambiguus. Two small vessels in this region, probably veins, were surrounded by a few lymphocytes, and similar cells infiltrated the leptomeninges on the right side. No definite damage to the nerve cells was noted.

Pons: Some of the nerve cells of the nucleus of the right seventh nerve were rounded and had undergone central chromatolysis (axonal reaction). No change in the hypoglossal or the cochlear nucleus was observed.

Cerebrum and Cerebellum: These areas were normal.

Skin: No inclusion bodies were observed. A section of a recent vesicle showed loss of epidermis and chronic inflammatory reaction in the dermis.

VIRUS STUDIES

Brain tissue was macerated with a pestle in a sterile mortar and mixed with enough isotonic solution of sodium chloride U. S. P. to make a suspension. One cubic centimeter of the mixture was placed on the scarified cornea of one eye in each of 2 rabbits. One rabbit received an intracerebral inoculation with 1 cc. of the mixture, and a similar amount was used to inoculate either the cerebrum or the peritoneal cavity of 3 mice. None of the animals exhibited systemic neurologic or cutaneous signs. No

corneal exudate was seen in the rabbit. After one month the animals were killed. No gross or microscopic lesions were seen. Examination of the corneas of the rabbits, after fixation in Zenker's solution and staining with phloxine and methylene blue, revealed no inclusion bodies.

COMMENT

Microscopic Changes.—The microscopic changes in the spinal ganglia constitute the most striking and distinctive pathologic feature of herpes zoster. In our cases and in those of many other authors, notably von Bärensprung[1] and Head and Campbell,[2] the spinal ganglion corresponding to the vesicular eruption had undergone partial or complete necrosis, with a varying amount of hemorrhage. In cases 1 and 3 in our series both parenchymatous and interstitial elements were destroyed so completely as to resemble "infarct necrosis," a fact suggesting vascular occlusion as the cause. In case 1 thrombosis of a main vessel to the ganglion was noted. Careful search in case 3 revealed no certain evidence of thrombosis or rupture of vessels. Head and Campbell[2] and Hedinger[6] drew attention to proliferation of the intima and cuffing of vessels, but they were unable to incriminate any single vessel in the ganglia which they examined. These changes were also present in 2 of our cases. Within the area of necrosis there were remnants of eosinophilic cells, or "ghost cells." These were surrounded by an intense inflammatory reaction and by a few still viable nerve cells. The connective tissue capsule of the ganglion was invaded by lymphocytes. Inconspicuous neuronic degeneration was seen in neighboring ganglia on the same side, when these were examined, a lesion also described by Head and Campbell.[2] It therefore appears unlikely that vascular thrombosis is primary in the disease, although the massive character of the focal necrotic lesion is strongly suggestive of vascular obstruction.

Hemorrhages into the ganglion, when present, appear to arise from small vessels in the necrotic region. In our case 1 and in a case cited by Head and Campbell[2] the hemorrhages were present in the peripheral nerve and in the cutaneous vesicles, as well as in the ganglion. In case 3 there was some extension of necrosis into the peripheral portion of the root. In case 1 the area of necrosis did not involve the whole ganglion, as Head and Campbell[2] also noted in some cases. In case 2 the ganglion appeared to be replaced by a cavity, along which ran the intact anterior root. The absence of inflammatory reaction in and around this cystlike cavity, only twenty-three days after the onset of the zoster, led us to question whether the spinal ganglion had escaped microscopic section. Complete destruction, however, has been noted in cases reported by Head and Campbell after a longer interval. In our case 3 the whole second cervical spinal ganglion was necrotic.

The changes in the dorsal nerve roots reflect the amount of damage in the ganglia. The change was a simple wallerian degeneration, with occasional patches of lymphocytic infiltration extending to the zone of entry of the root in the spinal cord. The isolated cellular changes in the adjacent ganglia were not usually accompanied by alteration of the dorsal roots.

All 3 cases in our series illustrate the extensive inflammatory changes in the central nervous system, first completely described by Lhermitte and Nicolas,[3] Wohlwill,[7] Faure-Beaulieu and Lhermitte[8] and others under the name "zoster myelitis." In the gray matter of the posterior and anterior horns of the spinal cord there was conspicuous proliferation of microglia cells, extending two or more segments from the one in which the cutaneous eruption occurred. This microglial reaction was accompanied by lymphocytic infiltration around veins and was strictly unilateral. A few plasma cells were noted in the infiltrations, as described by Lhermitte and Nicolas.[3] There was a mild meningeal infiltration, also of lymphocytes, over the affected segments of the cord, together with a corresponding reaction around the nerve roots; this focus was no doubt the origin of the persistent lymphocytosis in the spinal fluid. As previous investigators have noted, this inflammatory reaction is accompanied by scattered, but definite, damage to nerve cells, which in our cases was observed in the anterior horn, the substantia gelatinosa and Clarke's column on the affected side. Sections of cord stained by the Marchi method revealed the severe degeneration of the intramedullary portion of the dorsal root (fig. 13), medial to the dorsal horn, as described by a number of investigators. It will be noticed that the microglial reaction in corresponding Nissl sections (figs. 10 and 11) was distributed widely through the gray matter, and was not merely a secondary reaction to myelin degeneration. The microglial proliferation, the lymphocytic infiltration of the perivascular spaces and meninges and the necrosis and neuronophagia

6. Hedinger, E.: Beitrag zur Lehre vom Herpes zoster, Deutsche Ztschr. f. Nervenh. **24**:304-319, 1903.

7. Wohlwill, F.: Zur pathologischen Anatomie des Nervensystems vom Herpes zoster, Ztschr. f. d. ges. Neurol. u. Psychiat. **89**:170-212, 1924.

8. Faure-Beaulieu, M., and Lhermitte, J.: Les lésions médullaires du zona idiopathique: La myélite zostérienne, Rev. neurol. **1**:1250-1258, 1929.

of nerve cells combine to form a histopathologic picture which is characteristic of neurotropic virus infections. This disease is strictly a poliomyelitis; in none of our cases was there observed any demyelination, such as was described in 1 case by Lhermitte and Vermès,[9] the condition being complicated, however, by the presence of syphilis.

In cases 1 and 3 there was extensive degeneration of the anterior roots in their course past the corresponding necrotic ganglia. In case 3 the second cervical anterior root was completely degenerated at this point. The degree of degeneration of the motor roots in both cases exceeded the sparse necrosis of the anterior horn cells and appeared to indicate a true motor radiculitis.

This inflammatory reaction, so intense in the ganglia, spinal nerve roots and spinal cord, extended in milder degree into the peripheral nerves. A complete examination of peripheral nerves was not made in any of our cases, but we observed an intense inflammatory change in the intercostal nerve and in cutaneous filaments in case 1.

In summary, we affirm four histologic events which distinguish herpes zoster from other pathologic processes: 1. A ganglionitis marked by pannecrosis of all or part of the ganglion, with or without hemorrhage and surrounded by intense lymphocytic infiltration. This phenomenon was, in all published accounts and in our own cases, associated with the eruption of vesicles characteristic of the disease in the corresponding cutaneous segment. Wohlwill[7] alone claimed that inflammation of a nerve root or of a peripheral nerve can, without the necrotic ganglionitis, account for the zoster. 2. A poliomyelitis which closely resembles anterior poliomyelitis but is readily distinguished by its unilaterality, segmental localization and greater involvement of the posterior horn, posterior root and dorsal spinal ganglion. 3. A relatively mild, localized leptomeningitis, in which the cellular infiltrate is relatively slight and limited principally to the involved spinal segments and nerve roots. 4. True peripheral mononeuritis, seen not only in the nerves distal to the ganglion but in the anterior nerve root, both within the meninges and in the portion contiguous to the involved spinal ganglion. These pathologic changes are substratum for the neuralgic pains, the persistent pleocytosis and the local palsies which may attend and follow the zoster infection. There was no evidence of the location of fresh disease corresponding to the fresh crop of vesicles in case 3 on the fifty-second day of the illness, but the extensive inflammatory changes and the persistent pleocytosis indicated continued activity of the pathogenic agent.

9. Lhermitte, J., and Vermès: Les lésions du système nerveux centrale dans la zona, Rev. neurol. **1**: 1231-1236, 1930.

HERPES ZOSTER IN THE TERRITORY OF THE CRANIAL NERVES

The hypothesis of Hunt[4b] that the combination of a herpetic eruption in the external auditory meatus and palsy of the facial nerve is due to herpes of the geniculate ganglion has wide acceptance, in spite of the absence of pathologic proof. The hypothesis is attractive by reason of the explanation of the involvement of a motor nerve, a curiously localized area of cutaneous eruption and the frequency of association of these two lesions.

Prior to the first papers of Hunt,[4b] the sign of involvement of the pars intermedia and the geniculate ganglion associated with a lesion of the seventh nerve, according to the classic description by Erb,[10] had been a coexistent paralysis of the palate on the same side. The motor supply of the palatal muscles by the greater superficial petrosal nerve had already been questioned in 1907, but cases of palatal herpes and facial palsy, with or without auricular herpes, led Hunt[11] later to modify his hypothesis and include the soft palate as an alternative or additional area of sensory innervation by the geniculate ganglion. He also included a case in which the cutaneous eruption was limited to the posterior aspect of the pinna and the cleft between the ear and the mastoid process as illustrating an aberrant sensory distribution of the geniculate ganglion. Hunt provided an attractive argument for this variability in sensory supply of the geniculate ganglion based on the comparative anatomy of the seventh nerve and its branchial segment.

Whereas the hypothesis of "geniculate herpes" might explain the aforementioned strange sites of the eruption in association with palsy of the facial nerve, it encounters difficulty when the vesicles are found over the whole palate and within the nasal cavity on the affected side, as in the cases cited by Wakeley and Mulvaney,[12]

10. Erb, W. H.: Diseases of the Peripheral Cerebrospinal Nerves, in Ziemssen, H.: Cyclopaedia of the Practice of Medicine, New York, W. Wood & Co., 1876, vol. 11.

11. Hunt, J. R.: The Sensory Field of the Facial Nerve: A Further Contribution to the Symptomatology of the Geniculate Ganglion, Brain **38**:418-446, 1915.

12. Wakeley, C. P. G., and Mulvaney, J. H.: A Rare Feature of the Ramsay Hunt Syndrome, with Some Observations on the Sensory System of the Seventh Nerve, Lancet **1**:746-749, 1939.

in which the lesions were attributed to involvement of the petrosal nerve, or when the eruption is localized to the anterior two thirds of the tongue without loss of taste, as in the case cited by Gowers.[13] Conversely, well established combinations of gasserian and geniculate zoster with meatal and tympanic eruption without palsy of the facial nerve, like that in the case described by O'Shea,[14] or gasserian and geniculate ganglionitis and facial palsy without auricular, postauricular or palatal eruption, which Spillane[15] and Wilson[16] reported as another variety of the geniculate syndrome, raise a doubt whether the motor division of the seventh nerve is damaged by an associated inflammation of the geniculate ganglion.

Kidd[17] questioned whether the geniculate ganglion supplies the cutaneous area of the meatus, the doubt being based chiefly on anatomic evidence that no such cutaneous area has been proved to exist in any animal group higher in the scale than cyclostomes. Sherrington[18] demonstrated that the cutaneous zone of the external auditory meatus, which retains sensation in the cat and monkey after section of the fifth cranial and the second cervical nerve root, is innervated by the vagus nerve in the cat. Convincing demonstration that the pars intermedia of the seventh nerve has nevertheless some sensory reference to the deep portion of the external auditory meatus was recently supplied by Furlow,[19] who stimulated this nerve in its meningeal course at open operation in a conscious patient and thereby duplicated the pain of meatal neuralgia. No definite area of loss of sensation was demonstrated after section of the nerve. In the same manner, Reichert[20] demonstrated that the glossopharyngeal nerve supplies the same region, without loss of sensation in the area on section. In both these cases paroxysmal neuralgia had occurred in the area of meatal innervation and was relieved by section of the appropriate nerve. The possibility of some overlapping sensory innervation of the tympanic portion of the meatus by all three nerves, the pars intermedia, the glossopharyngeal and the vagus, must therefore be conceded. Of these, the vagus nerve, through the branch called the nerve of Jacobsen, has apparently the largest share.

In case 3 the geniculate ganglion was entirely unaffected, in spite of cutaneous eruption in the meatus and, later, postauricular eruption of the type also attributed by Hunt to involvement of the geniculate ganglion. An explanation for the various areas of eruption is to be sought in the involvement of other ganglia. We regret that the ganglia of the vagus and glossopharyngeal nerves were not examined in our case, but from the occurrence of a circumscribed microglial reaction in the lateral portion of the medulla, we suspect that one of these ganglia was involved. The extremely localized areas of cutaneous eruption which can occur within the territory of the fifth nerve (nasal cavity; tongue) and the patchy involvement of ganglion cells in ganglia other than the one which is the chief focus of necrosis both give warning, however, that narrow limitation of the cutaneous eruption may mean only a localized, partial lesion of the gasserian ganglion. Nor is it certain that herpes zoster does not on occasion affect the geniculate ganglion. If geniculate herpes is to be established as a pathologic entity, careful microscopic examination of all the cranial nerves and ganglia in a series of cases will be necessary, a study advocated by Mills[21] in an early criticism of the "geniculate syndrome."

Our case 3 indicates clearly, however, that damage to the seventh nerve can occur in the course of herpes zoster by the mechanism of an independent motor neuritis not directly related to inflammation of any ganglion. This observation at once removes one necessity for Hunt's hypothesis, namely, the mechanism of damage to the seventh nerve, and provides an explanation of the occasional involvement of oculomotor nerves in the course of ophthalmic herpes.

SUMMARY AND CONCLUSION

The dorsal root ganglion corresponding to the area of herpetic eruption was the site of inflammatory necrosis in 2 cases of herpes zoster,

13. Gowers, W. R.: A Manual of Diseases of the Nervous System, ed. 2, Philadelphia, P. Blakiston's Son & Co., 1900, vol. 2, p. 241.

14. O'Shea, H. V.: Otitis Herpes Zoster, Practitioner **125**:741-748, 1930.

15. Spillane, J. D.: Bell's Palsy and Herpes Zoster, Brit. M. J. **1**:236-237, 1941.

16. Wilson, S. A. K.: Neurology, Baltimore, Williams & Wilkins Company, 1940, vol. 1, p. 678.

17. Kidd, L. J.: The Alleged Sensory Cutaneous Zone of the Facial Nerve of Man, Rev. Neurol. & Psychiat. **12**:393-410, 1914.

18. Sherrington, C. S.: Reflexes Elicitable in the Cat from Pinna, Vibrissae and Jaws, J. Physiol. **51**: 404-431, 1917.

19. Furlow, L. T.: Tic Douloureux of the Nervus Intermedius (So-Called Idiopathic Geniculate Neuralgia), J. A. M. A. **119**:255-259 (May 16) 1942.

20. Reichert, F. L.: Tympanic Plexus Neuralgia, J. A. M. A. **100**:1744-1746 (June 3) 1933.

21. Mills, C. K.: The Sensory Functions Attributed to the Seventh Nerve, J. Nerv. & Ment. Dis. **37**:273-284 and 355-379, 1910.

and in a third case a cyst replaced the ganglion. In all 3 cases there were degeneration of the related motor and sensory roots, severe neuritis, unilateral segmental poliomyelitis and localized leptomeningitis. These pathologic changes constitute a distinct neuropathologic syndrome and provide an explanation for such commonly observed clinical events as neuralgia, motor palsies and pleocytosis.

The third case in our series, one of auricular and occipital herpes with palsy of the facial nerve, is of considerable interest because of the rarity of cases with autopsy. Here a typical necrotizing ganglionitis (second cervical ganglion) and motor neuritis of the facial nerve without damage to the geniculate ganglion were observed. It is concluded that the phenomena of herpes zoster require more than the ganglionic lesion for their explanation, but depend in part on a poliomyelitis and motor neuritis. Application of these deductions to the syndrome described by Ramsay Hunt allows an explanation of the facial palsy occurring in the course of cranial herpes zoster without implication of the geniculate ganglion.

Analysis reveals that the evidence for geniculate ganglionitis in the "Ramsay Hunt syndrome" is invalid. It is possible that some of the various herpes zoster syndromes with palsy of the facial nerve depend on the concurrent involvement of two or more cranial nerves.

Neurological Unit, Boston City Hospital.

ELECTRONARCOSIS IN ANIMALS AND IN MAN

J. P. FROSTIG, M.D.; A. VAN HARREVELD, M.D.; S. REZNICK, M.D.; D. B. TYLER,* PH.D., AND C. A. G. WIERSMA, PH.D.

PASADENA, CALIF.

In the beginning of this century Leduc [1] produced a narcosis-like state in rabbits and in dogs by applying a unidirectional pulse current to the central nervous system. The cathode was placed on the head and the anode on the sacrum. "Electronarcosis" was started by application of a relatively high current, which caused strong contractions of the body musculature. The animal fell on its side; respiration stopped, and the bladder, and sometimes the rectum, were emptied. After a few seconds the current was decreased to a level at which respiration returned. The animal remained motionless as long as the current was maintained (1 to 4 milliamperes, as measured with a ballistic galvanometer) and could not be aroused even by strong stimuli. Electronarcosis could be maintained for an indefinite time. As soon as the current was interrupted, the animal awoke, without any apparent ill effects.

Leduc's observations have been confirmed by several investigators (von Neergard,[2] Zimmermann [3]). Some authors, however, observed strong excitatory phenomena during the application of a pulsating current to the central nervous system (Sack and Koch,[4] Koch and Sack,[5] Samssonow [6]).

Leduc, assisted by Malherbe and Rouxeau,[7] tried out the procedure on himself. The pulsating current was slowly increased. At the beginning of the application unpleasant sensations were experienced at the site of the electrodes. These sensations ceased on further increase of the current. The first sign of central involvement was his inability to speak; soon afterward he was unable to move, although he still remained conscious. During the application of the strongest current that Malherbe and Rouxeau dared to give, Leduc heard what was said, but perception was "dreamlike" and painful stimuli were felt as though they were applied to an extremity deeply asleep. A few years later Tuffier and Jardry [8] and Leclerc [9] used electronarcosis in a few clinical operations on animals and on man, apparently with some success.

It has been shown that there is a fundamental difference between the mechanism of electronarcosis and that of chemical narcosis (van Harreveld, Plesset and Wiersma [10]), since the narcotic action of the electric current depends on its stimulating effect. This difference is well illustrated by the fact that the metabolism of the brain, which is reduced in chemical narcosis, remains practically unchanged during electronarcosis (van Harreveld, Tyler and Wiersma [11]). In view of the work of Leduc, answers were

From the William G. Kerckhoff Laboratories of the Biological Sciences, California Institute of Technology, Pasadena, Calif., and Patton State Hospital, Patton, Calif. This investigation was carried out with the support of the Department of Institutions of the State of California.

* Hixon Fund Fellow.

1. Leduc, S.: Production du sommeil et de l'anesthésie générale et locale par les courants électriques, Compt. rend. Acad. de Paris **135**:199-200 and 878-879, 1902; Ann. d'électrobiol. **5**:526-527, 1902; Production du sommeil et de l'anesthésie générale et locale par les courants intermittents de basse tension, Arch. d'électric. méd. **10**:617-621, 1902; L'électrisation cérébrale, ibid. **11**:403-411, 1903; La narcose électrique, Ztschr. f. Elektrother. **5**:374-381 and 403-410, 1903; Der elektrische Schlaf, Arch. phys. Med. u. med. Techn. **5**:3-15, 1911.

2. von Neergard, K.: Experimentelle Untersuchungen zur Elektronarkose, Arch. f. klin. Chir. **122**:100-150 1922.

3. Zimmermann, J.: Untersuchungen über die Anwendbarkeit der elektrischen Betäubung nach Leduc bei chirurgischen Eingriffen an Hunden, München. tierärztl. Wchnschr. **80**:121-124, 141-145 and 155-159, 1929.

4. Sack, G., and Koch, H.: Zur Frage der sogenannten Elektronarkose durch wiederholte Gleichstromstösse, Ztschr. f. d. ges. exper. Med. **90**:349-364, 1933.

5. Koch, H., and Sack, G.: Elektronarkoseversuch: Untersuchungen über die Wirkung periodischer rechtwinkliger Gleichstromstösse, Ztschr. f. d. ges. exper. Med. **90**:365-377, 1933.

6. Samssonow, N.: Beitrag zum Studium der Elektronarkose, Arch. f. d. ges. Physiol. **232**:554-558, 1933.

7. Leduc, S.; Malherbe, A., and Rouxeau, A.: Production de l'inhibition cérébrale chez l'homme par les courants électriques, Compt. rend. Soc. de biol. **54**:1297-1299, 1902.

8. Tuffier and Jardry: Les applications du sommeil électrique a la chirurgie expérimentale, Presse méd. **15**: 259, 1907.

9. Leclerc, G.: L'anesthésie eléctrique chez l'homme, Cong. franç. de chir. **23**:665, 1910.

10. van Harreveld, A.; Plesset, M. S., and Wiersma, C. A. G.: The Relation Between the Physical Properties of Electric Currents and Their Electronarcotic Action, Am. J. Physiol. **137**:39-46, 1942.

11. van Harreveld, A.; Tyler, D. B., and Wiersma, C. A. G.: Brain Metabolism During Electronarcosis, Am. J. Physiol. **139**:171, 1943.

sought to the following questions: Can a method be devised by which the human brain can be exposed to the action of an electric current for periods longer than a fraction of a second, as used in electric shock? What are the symptoms caused by this procedure? Is such a method compatible with the safety of the patient? In order to obtain an answer to these questions, first animals and subsequently human subjects were exposed to the prolonged action of the current applied to the brain.

CHOICE OF CURRENT AND APPARATUS

Leduc expressed the opinion that the only current capable of producing electronarcosis was a unidirectional pulsating current with a frequency of about 100 per second and a pulse duration of one millisecond. It was found later, however, that a 50 cycle, sinusoidal alternating current also is suitable for induction of electronarcosis (van Harreveld and Kok [12]). Recently it has become evident that any current capable of stimulating the central nervous system can be used to produce electronarcosis (van Harreveld, Plesset and Wiersma [10]). Any variation in current of sufficient duration and slope will cause such a stimulation. Since the central nervous system must be stimulated for the entire duration of electronarcosis, these variations in current must be repeated with suitable frequency. Thus it is not surprising that pulsating, as well as alternating, current can cause electronarcosis and that direct current, which has hardly any stimulating properties except during the onset, is less suitable for this purpose (Tschagowetz [13]; Silver [14] van Harreveld, Plesset and Wiersma [10]). Since alternating current is the most readily available, this form of electricity has been used in all the present experiments. Because of the difference in the local supplies of current in Pasadena and in Patton, the animal experiments were carried out with a 60 cycle current and the experiments on human subjects with a 50 cycle current. Experiments on dogs have shown that the symptoms of electronarcosis produced by currents of these two frequencies are the same.

In a large number of the experiments on dogs and in all applications of current to human subjects an apparatus based on the principle of current control described by Plesset [15] was used. This apparatus automatically compensates for moderate changes in resistance in the subject's circuit. Changes in the resistance of the electrode contacts, which are hardly avoidable in a restive subject, are therefore of no consequence, since the current passing through the head remains constant. The maximum output of this apparatus is 250 milliamperes.

In the animal experiments electrodes, 2 cm. in diameter, were placed on both sides of the skull directly behind the eyes. With the human subjects square electrodes, measuring 5 by 5 cm., were used. Except in the investigations on the influence of placement of electrodes, the electrodes were placed on the temples. To assure a good contact an electrode paste was applied between the electrodes and the skin. The electrodes were kept in place by bandages.

In all animal experiments the pulse rate and the respiratory rate were obtained in the usual way. The blood pressure was determined in some experiments by connecting a large artery (the femoral or the carotid) with a recording mercury manometer. In the work with patients the blood pressure was measured by the auscultatory method in one of the arms, and the heart rate was determined by means of a stethoscope taped over the region of the apex beat. These determinations were made at alternate half-minute intervals for the entire duration of the electronarcosis and for some time afterward.

OBSERVATIONS

Various methods of induction of electronarcosis were studied, first in dogs and later in human subjects. In the latter the influence of various placements of the electrodes was studied. Since with respect to the safety of the procedure the reactions of the circulatory apparatus are of primary importance, the influence of electronarcosis on the heart and blood vessels will be described in a special section. In addition, the results of studies on the chemical constituents and the morphologic features of the blood will be presented.

The observations were made on adult dogs of various kinds, sizes and ages and on patients of both sexes with a history of dementia precox of at least four years' standing. The age of the patients varied from 20 to 45 years.

Symptoms of Electronarcosis in Dogs.—The following standard procedure for the production of electronarcosis was employed: A relatively strong current (e. g., 300 milliamperes of a 60 cycle alternating current) was applied for thirty seconds, after which the current was decreased in strength (e. g., to 50 milliamperes).

Immediately on application of the strong current, the legs flexed actively, and the standing animal fell. The period of flexion was very short, and for the next few seconds the legs were without tone. After the current had been applied for five to ten seconds, however, a strong

12. van Harreveld, A., and Kok, D. J.: Ueber Elektronarkose mittels sinusoidalen Wechselstromes, Arch. néerl. de physiol. **19**:24-57, 1934.

13. Tschagowetz, W.: Ueber die Veränderung der reflektorischen Erregbarkeit des intermittierenden galvanischen Stromes auf das Zentralnervensystem, Arch. f. d. ges. Physiol. **146**:567-577, 1912.

14. Silver, M. L.: Electrical Anesthesia in Rats, Proc. Soc. Exper. Biol. & Med. **41**:650-651, 1939.

15. Plesset, M. S.: Current Control in Electroshock Therapy, Proc. Soc. Exper. Biol. & Med. **49**:530-532, 1942.

extensor spasm developed in the legs. In addition there was opisthotonos. The position of the animal at this time resembled closely that of pronounced decerebrate rigidity. There was complete respiratory arrest. This state remained unchanged as long as the strong current was applied. In most experiments urine was passed during this period, and sometimes a bowel movement occurred. Immediately on application of the current the heart was arrested for a few seconds; it then started to beat again, beginning at a very low rate.

The decrease in the strength of the current after thirty seconds resulted in relaxation of the extensor spasm and the appearance, within a few seconds, of clonic twitches, which receded spontaneously in a short time (five to ten seconds). Sometimes, instead of clonic twitches, coarse shaking was observed.

If the current had been decreased sufficiently, the first respiratory movement occurred fifty to seventy seconds after the beginning of the experiment. If the decrease in current was insufficient, the return of respiration was delayed, but breathing could be established by further diminishing the current. At first respiration was gasping and infrequent, but soon breathing became more normal. The intensity of current at which adequate respiration was possible depended on the type of current used and the individual reaction of the animal, and probably on the placement of the electrodes. Usually 40 to 70 milliamperes of a 60 cycle alternating current was compatible with adequate respiration.

After regular respiration had been established, the animal lay quietly and without tone in the muscles, although sporadically light clonic twitches might occur. If respiration at this time was still inadequate, improvement could be achieved by a slight decrease in the strength of the current. The highest level of current which was compatible with adequate respiration has been designated the narcosis level.

During the subsequent course of application of the current one of two syndromes might develop; these have been distinguished as the narcotic and the kinetic type of electronarcosis. The narcotic type is a continuation of the state just described. In this state the animal lay quietly, breathing slowly and deeply. Respiration might be somewhat labored and noisy. Von Neergard [2] found that this stertorous breathing was due to contraction of the vocal cords, which impeded the passage of the air. After tracheotomy respiration was perfectly free. In this form of electronarcosis the heart rate was low, about half the normal rate. The animal showed no spontaneous activity except for respiratory movements, and in some cases occasional clonic twitches. The front legs were usually extended and the hindlegs semiflexed. This is the typical position of dogs when no pronounced tone prevails. Positive and negative supporting reactions (Rademaker [16]) were present when the legs were placed in the proper positions. In particular, the front legs when brought into the position for standing became more or less rigid. Nevertheless, when the animal was placed on its legs, it was not able to stand. Except for the positive supporting reaction, no appreciable tone was present in the legs. The head was usually dorsally extended, and the eyes were tightly closed; these symptoms may be ascribed to direct stimulation of the muscles involved. Tendon reflexes, such as the knee jerk, were usually of about normal excitability. No righting reflexes could be elicited. Pinching or pricking the skin produced no reaction. The pupils were usually in middilatation, and the pupillary reaction to light, if present, was sluggish. Pressure on the eyeballs through the closed eyelids was often without effect but sometimes caused defecation or irregularities of respiration. Many dogs from time to time had a spontaneous bowel movement. Once this narcotic type of electronarcosis was established, it could almost invariably be maintained for hours.

Increase of the current beyond the value necessary to maintain this state caused an extensor tone in the legs which was independent of the position of the legs. Respiration became more difficult, owing to contraction of the glottis, and was sometimes inadequate. In most animals this occurred when the current was increased about 20 milliamperes above the narcosis level. Sudden increases in the current might arrest respiration, whereas the same increase extended over several minutes might not produce any notable change in the rate of breathing.

As the current was decreased below the level at which the narcotic effect of electronarcosis was obtained, the supporting reaction became stronger and stronger until the animal, when placed on its legs, remained in a standing position. Even in this state there was no return of spontaneous movements, of righting reflexes or of reactions to cutaneous stimuli. When the legs were placed in abnormal positions, no corrective movements were made. These cataleptic phenomena have been observed before on application

16. Rademaker, G. G. J.: Das Stehen, Berlin, Julius Springer, 1931.

of current to the head (Keller,[17] van Harreveld and Kok [18]). If during this cataleptic state the current was slowly increased, a reversal of the phenomena could be obtained, and the narcotic state could be reestablished. The difference in currents producing these two states was about 20 milliamperes. When during prolonged electronarcosis the current was kept at the same level, the narcotic state changed slowly into the cataleptic state. Therefore, to maintain a constant depth of electronarcosis for long periods the narcotizing current must be gradually increased.

When the current was turned off during a period of electronarcosis of the narcotic type, the animal recovered in the course of a few minutes, usually passing through a transitional period of catalepsy.

The second, or kinetic, type of electronarcosis was characterized by frequent attempts of the animal to right itself, movements which were often ataxic and usually unsuccessful. These attempts might develop into violent and disordered hyperkinesis of the head and extremities, which was often preceded or accompanied by yelping or whining. Between righting attempts the animal was quiet, but righting and hyperkinesis could be induced by certain stimuli, the most effective of which was pressure on the eyeball. Also effective was moving the animal, inducing stimulation of the vestibular apparatus, and perhaps other sensory systems. In some cases cutaneous stimuli were effective. The heart and respiratory rates were higher in this type of electronarcosis than in the narcotic type, and as a rule were higher than normal. When the current was decreased, the placing reaction could often be elicited. Increase of the current produced pronounced extensor tone in the legs, and the hyperkinetic symptoms might become aggravated. Once the hyperkinetic type of electronarcosis became pronounced, neither increase nor decrease in the current was effective in changing it into the narcotic type. If the current was cut during the hyperkinetic type of narcosis, immediate recovery without cataleptic symptoms followed. After awakening the animal often panted and showed excitement for several minutes.

The hyperkinetic type of electronarcosis was less frequent than the narcotic type. Often some kinetic symptoms, such as an occasional weak attempt of the animal to right itself, temporary yelping or movements on pressure on the eyeball, were observed during electronarcosis of the narcotic type. The type of electronarcosis produced is largely an individual reaction of the animal. However, in the course of a long series of inductions of electronarcosis in the same animal, kinetic symptoms may appear or, if present at first, may become aggravated. Occasionally hyperkinetic symptoms may become increasingly apparent in the course of a prolonged period of narcosis.

Several variations in the procedure were investigated; the results of the more important ones may be described. It was attempted to produce electronarcosis by slowly increasing the current to the narcosis level instead of starting with an initial strong current of thirty seconds' duration and subsequently decreasing it to the narcosis level. In these experiments only dogs in which the standard procedure caused electronarcosis of the narcotic type were used. In most animals this method of application of current resulted in a violent hyperkinetic type of electronarcosis, and only in a few could a narcotic type be obtained. The flexion and the secondary extensor spasm observed during application of the strong initial current in the standard procedure were absent with this method. In the few experiments in which a narcotic type of electronarcosis was obtained with this procedure, the animal toppled over slowly, without any hyperkinetic symptoms. In another series of experiments, shortening of the duration of the strong initial current resulted in a greater frequency of hyperkinetic symptoms than was encountered with the standard procedure. The same effect was noted when the strength of the initial current was materially decreased. In the latter experiments a slow, late development of the extensor spasm was observed.

Symptoms of Electronarcosis in Man.—More than 100 electronarcoses were induced in a series of 9 patients. All the patients had shown signs of dementia precox for over four years. In all but 1 patient evidence of schizophrenic deterioration was observed. These patients were selected because thorough physical and laboratory examinations showed no evidence of organic disease.

The method of induction of electronarcosis in human subjects was similar to the standard method described for dogs. For reasons of safety, the initial strength of current chosen was relatively low, between 150 and 250 milliamperes. This initial current was maintained for thirty seconds, after which it was decreased to the level at which respiration became possible. In man

17. Keller, C. J.: Experimentelle Katatonie durch elektrische Hirnreizung, Acta brev. Neerland. **1**:100-101, 1931.

18. van Harreveld, A., and Kok, D. J.: Ueber experimentelle Katalepsie durch sinusoidalen Wechselstrom, Arch. néerl. de physiol. **19**:265-289, 1934.

this level was somewhat higher than in dogs (45 to 90 milliamperes).

On initiation of the current the arms were suddenly brought forward and outward and the elbows were flexed. The legs were flexed at the hips and the knees. These contractions were lightning-like. They were sometimes absent when the experiment was started with a low initial current (150 milliamperes). The initial flexion was followed by a phase of rigidity. Sometimes a period of flaccidity was observed between the initial flexion and the rigidity. During the phase of rigidity the lower extremities were usually maximally extended. The abdominal and thoracic muscles were also maximally contracted, the chest being fixed in a position of maximal inspiration. The head was usually dorsally extended; however, absence of the dorsal extension or a rigid flexed position of the head was sometimes noted. The position of the arms showed the greatest variation. They were either abducted or adducted, flexed or extended. The hand was in the tetanic position or clenched into a fist, with the thumb often wedged in between the second and the third finger. Asymmetric positions of the arms, with extension on one side and flexion on the other, were frequently seen. Sometimes changes in posture from flexion to extension and vice versa were noted.

Application of the strong current was immediately followed by arrest of the heart, which lasted a few seconds; then the heart resumed its action at a low rate (not higher than 20 beats per minute). During application of the high initial current there was complete arrest of respiration. After the first few seconds the face, and sometimes the neck and thorax, became flushed. The eyes were kept tightly closed. When they were pried open, conjugate deviation was often observed. The pupils were usually constricted and did not react to light. A pilomotor response was frequently observed. In women an erection of the nipple was often seen.

The level of current at which adequate respiration became possible was rather constant in successive narcoses in the same patient, but was of course not known at the first application. Therefore, at the first induction of electronarcosis the current was decreased to a low level (50 or 60 milliamperes) after thirty seconds. If respiration started readily, a higher level of current was tried at the next application. If the return of respiration was delayed and the current had to be decreased in order to obtain adequate respiration, a lower level was tried the next time.

The decrease in the high initial current was followed by disappearance of the rigidity. Coarse shaking and clonic twitches occurred and receded spontaneously after five to fifteen seconds. Respiration began usually between fifty and seventy seconds after the first application of the current. At first a few gasps were made, which were shortly followed by more normal respiratory movements. Respiration was at first shallow but soon became deeper. It was often strained and noisy, probably because of contraction of the glottis. A decrease of only a few milliamperes abolished this effect. When the initial current was too low, respiration might be resumed almost immediately after its decrease. During the arrest of respiration the face, lips and nails became cyanotic. Usually the cyanosis was not severe and receded quickly when respiration was again established. When the contraction of the glottis prevented the free passage of air, however, cyanosis might be more severe. The changes in heart rate during this period were complicated and will be discussed later.

After respiration had been restored, a few minutes followed in which the body was relaxed and no active movements were seen. In this period no reflexes could be elicited. The knee jerk and the achilles and flight reflexes were all absent. The pupils were usually constricted and did not react to light, and the corneal reflex was absent. In this phase the face was often still flushed. If no further changes were made in the current, this passive state lasted three to five minutes. Then spontaneous movements which had the character of primitive movements appeared. From time to time righting attempts were made; the supine patient tried to roll over on his side or to sit up. These attempts were at first of short duration and were usually unsuccessful. Later intentional movements appeared. Crude attempts to remove the electrodes or to adjust the clothing and coverings were made. In some patients the motor activity became more pronounced and was finally difficult to control. Simultaneously with these phenomena reflexes returned. The knee jerk and the achilles reflex could be elicited with increased ease and might even be hyperactive. Sometimes the knee and foot clonus could be elicited. Stimulation of the sole usually produced the flight reflex, but in some patients this stimulus elicited the reflex of Babinski. Forced grasping could be elicited. Finally the corneal reflex returned, and the pupils, which in the meantime had been in middilatation, reacted to light. Defense movements sometimes occurred on painful stimulation, although these movements were crude and their localization was uncertain. The appearance of

intentional movements was indicative of the approaching restoration of cortical functions. All these symptoms were likely to occur earlier if the arrest of respiration was shorter than usual.

The respiratory frequency and the heart rate in human subjects during electronarcosis were higher than normal once the initial symptoms were over. The frequencies increased even more when restlessness was pronounced.

Consciousness was lost during the entire period of application of the current; some patients reported remembering a flash of light at the very start of the treatment, which may have been due to the stimulation of the optic system by the high initial current. No patient complained of any unpleasant sensations during electronarcosis. In some cases in which electronarcosis was continued until intentional movements were pronounced, the patient reported having a dim recollection of the very last part of electronarcosis. Even in these cases no pain or other unpleasant sensation was experienced. Termination of electronarcosis is indicated, nevertheless, when the appearance of intentional movements reveals the resumption of cortical activity. In other experiments the development of uncontrollable restlessness made termination necessary. For these reasons electronarcosis was limited in duration to five or ten minutes. Attempts were made to counteract the gradual awakening of central functions by increasing the current after the return of respiration. An early increase in current was found to be the most effective. After the appearance of primitive movements the effect of an increase in current was slight. After respiration was restored and cyanosis had receded, the current could be increased considerably, until stridulous respiration, indicating contraction of the glottis, forbade any further increase. For example, in an experiment in which the current had to be decreased to 70 milliamperes after the initial current (250 milliamperes) to obtain adequate respiration, it was possible to increase the current to 105 milliamperes during the following minutes before signs of respiratory impairment became noticeable. The current was changed slowly and cautiously, an increase of 5 milliamperes being made over a period of thirty seconds. Such an increase in current was accompanied by the development of moderate rigidity. The legs were kept extended, and the arms were flexed at the elbows.

This method of application of current usually delayed the development of the primitive movements slightly and retarded considerably the subsequent development of the other symptoms. In most patients it was possible to prolong electronarcosis in this way to from ten to twenty minutes, sometimes even to half an hour. In some patients, however, pronounced restlessness developed rather regularly after about seven minutes, so that it was necessary to terminate the narcosis at that time. It was never possible to prevent the awakening of central functions entirely.

Twice the slow increase in the current resulted in symptoms entirely comparable to the initial symptoms of electronarcosis. A strong extensor rigidity with arrest of respiration developed, a phase which, after the immediate cutting of the current, was followed by clonic twitches and restoration of respiration. These symptoms resulted from an increase in current at a late stage of electronarcosis, about ten minutes after the start.

Termination of electronarcosis resulted in general in a prompt and speedy return of consciousness. After a few minutes the patient reacted to his name and a few minutes later tried to answer questions. Two patients, both of whom exhibited considerable restlessness during electronarcosis, showed a persistent tendency to confusion and restlessness after termination of the narcosis. The reflex of Babinski, which developed in several instances during electronarcosis, persisted for some minutes afterward. Sometimes this reflex developed after the current was cut and changed a few minutes later into the flight reflex.

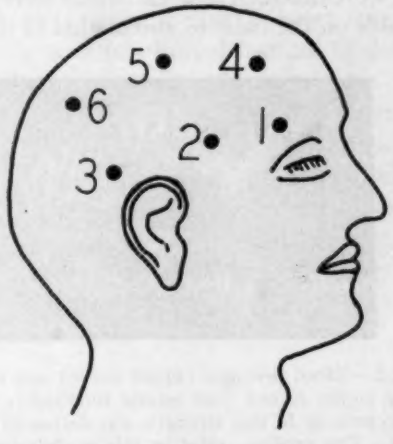


Fig. 1.—Location of the electrodes on the head in experiments to determine the influence of placement of electrodes on the symptoms of electronarcosis.

Effect of Placement of Electrodes.—In the dog placement of the electrodes in various positions on the head had no significant influence on the symptoms of electronarcosis. This was not unexpected, since in the dog the brain is small with respect to the size of the head, owing to the thickness of the bone and the muscle cover-

ings. These factors tend to produce a more or less equal distribution of the current in all parts of the brain irrespective of placement of the electrodes. In man the covering of the brain is much thinner in relation to its size, and localization of the current in certain parts of the human brain might therefore be possible.

The six electrode placements on the head shown in figure 1 were tried with 4 patients. The electrodes were placed symmetrically. Placement *2* was the standard location used in the applications of current previously described. The chief symptoms of electronarcosis were found to be the same regardless of the placement of the electrodes; thus they were similar to the symptoms described. The durations of the various phases were the same, and the characteristic variations for each patient were always present. Slight differences, characteristic of certain placements, were noted. These variations were readily explicable on the basis of stimulation of different

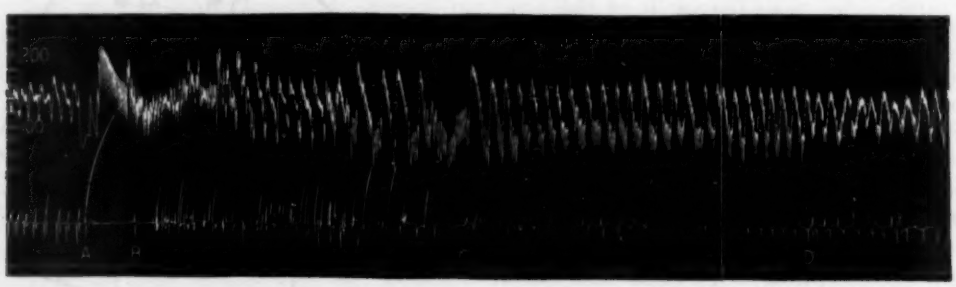


Fig. 2.—Blood pressure (upper curve) and respiration (lower curve) during electronarcosis. At the bottom is the time signal record (six second intervals). At *A* the initial current of 500 milliamperes was applied. After thirty seconds at *B*, this strength was decreased to 50 milliamperes, and at *C* it was further decreased to 45 milliamperes. The cardiac arrest in this experiment was rather long. The two parts of the curve are separated by an interval of five minutes, during which no significant changes in blood pressure and respiration were noted. The current was cut at *D*.

peripheral or central structures. Low placement of the electrodes (*1, 2* or *3*) resulted in profuse secretion of saliva and tears, which was scant or absent with placement of the electrodes high on the head (*4, 5* or *6*). When the electrodes were placed on the frontal part of the skull (*1, 2* or *4*) the pupils were constricted and did not react to light in the first part of the period of electronarcosis. With the electrodes on the occipital part of the head (*3, 5* or *6*) the pupils were more dilated and reacted earlier to light. With the occipital placements, *3* and *6*, more impairment of the respiration was encountered than with the more frontal placements. For practical purposes a placement between *2* and *5*, not too far occipital and as high as convenient with respect to the hair, seems to be the most suitable.

Influence of Electronarcosis on the Blood Pressure and the Heart Rate.—In the Dog: Several authors (Bikeles and Zbyszewski,[19] Ivy and Barry,[20] Roos and Koopmans,[21] van Harreveld and Kok [12]) have studied the effect on the blood pressure and the heart rate of the passage of a strong sinusoidal alternating current through the brain for a short period. As may be expected, the blood pressure curves obtained during the initial part of electronarcosis were in agreement with the observations of these authors. Immediately after the make of the high initial current, the heart stopped, with resulting drop in pressure (figs. 2 and 3 *I*). In most cases this arrest was of only a few seconds' duration, but occasionally it lasted longer. When the heart started beating again, the blood pressure increased with each beat and in this way climbed well above the prenarcotic value. The blood pressure reached a maximum either during the period of the high initial current or shortly afterward. The heart rate, which was always low during the initial current, often rose above the prenarcotic rate shortly after the decrease of the current to the narcosis level (fig. 3 *I*).

It has been shown by the aforementioned authors that bilateral severance of the vagus nerves prevents the initial arrest of the heart. Under these circumstances the heart speeded up immediately after application of the current, and the blood pressure rose to a high level (fig. 3 *III*). It can therefore be concluded that the initial arrest of the heart and the drop in

19. Bikeles, G., and Zbyszewski, L.: Ueber den Einfluss der Reizung des Gehirnes (Oblongata) mittels Wechselströme auf das herzhemmende und vasomotorische Zentrum sowie auf die Atmung, Arch. f. d. ges. physiol. **182**:157-172, 1920.

20. Ivy, A. C., and Barry, F. S.: Studies on the Electrical Stunning of Dogs, Am. J. Physiol. **99**:298-307, 1932.

21. Roos, J., and Koopmans, S.: Studies on the So-Called Electrical Stunning of Animals, Vet. J. **90**:232-245, 1934.

blood pressure were due to stimulation of the vagus nerves, either directly or via their center. The rise in blood pressure, which became especially pronounced after transection of the vagus nerves, was probably due to stimulation of the sympathetic system, resulting in general vasoconstriction.

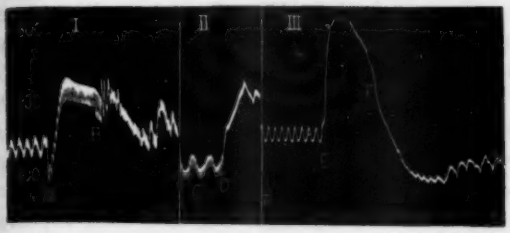


Fig. 3.—Influence of transection of the vagus nerves on the blood pressure during electronarcosis. The time interval is six seconds.

I, beginning of electronarcosis in an animal with the vagus nerves intact. At *A* the initial current of 500 milliamperes was applied, and after thirty seconds, at *B* it was decreased to 50 milliamperes. A short cardiac arrest caused a distinct drop in blood pressure.

II, part of the curve during electronarcosis, with a current of 50 milliamperes. The pulse rate was low. At *C* one vagus nerve was transected, and at *D*, the other. The pulse rate and blood pressure increased considerably.

III, after an interval of twenty minutes, during which no current was applied, the animal, in which the vagus nerves were now severed, was subjected again to electronarcosis. At *E* an initial current of 500 milliamperes was applied for thirty seconds, the strength of which was decreased to 50 milliamperes at *F*. The blood pressure and heart rate increased immediately after the beginning of application of the current.

The results of these experiments indicate that the typical blood pressure curve obtained in an animal with the vagus nerves intact results from simultaneous stimulations of the two systems. At first the influence of the vagus nerve prevails, with resulting cardiac inhibition and decrease in blood pressure. Afterward the heart escapes the influence of the vagus, and the effect of sympathetic stimulation becomes prevalent, with a rise in blood pressure above the prenarcotic level.

In the further course of electronarcosis the blood pressure, which was raised during the initial stages of electronarcosis, fell and from five to ten minutes after the start reached a value approximately equal to the prenarcotic level, where it remained for the rest of the experiment. In the narcotic type of electronarcosis, the heart rate was low (about half the normal rate) after the initial stages. It could be shown that this was due to a high vagal tone, since the injection of an appropriate amount of atropine or the transection of the vagus nerves speeded up the heart considerably (fig. 3 *II*). Transection of the vagus nerves caused a sharp initial rise in blood pressure, followed by a decline in the next few minutes. The pressure usually did not drop to the level which existed before severance of the vagus nerves. During the hyperkinetic type of electronarcosis the heart rate was usually higher than normal. The blood pressure curves during electronarcosis were characterized by large variations associated with the phases of respiration. Often a pronounced respiratory arrhythmia was present, especially when the respiratory rate was low (fig. 2).

During 2 experiments in which violent hyperkinesis had been present for several minutes, the animals died suddenly, probably of heart failure, since respiration continued for a short period after the pulse had stopped. Autopsy on 1 of these animals revealed pronounced edema of the lungs.[22] It is probable that the heart failure was due to the unusual effort demanded of the heart during the period of hyperkinesis.

Cessation of the current was often followed by a drop in blood pressure. This decrease was seldom pronounced, but it became considerable when, during the experiment, the animal was made to lose a large amount of blood. Under

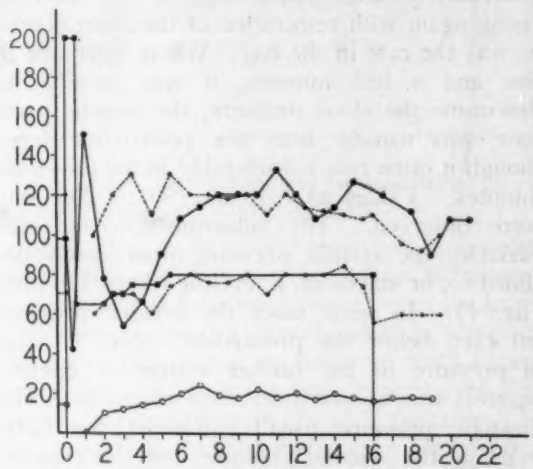


Fig. 4.—Blood pressure, heart rate and respiratory rate in a patient during electronarcosis of sixteen minutes' duration. The figures on the ordinate indicate the heart rate; the blood pressure, expressed in millimeters of mercury; the respiratory rate; and the current used to produce electronarcosis, expressed in milliamperes. On the abscissa is plotted the time, in minutes. The solid line marked with squares indicates the changes in strength of current; the solid line with the dots, the changes in heart rate; the broken lines, the systolic and diastolic blood pressures, and the solid line marked with circles, the changes in respiratory rate.

22. Dr. E. M. Hall, of the University of Southern California, examined the lungs.

these circumstances death occurred sometimes a few minutes after the termination of electronarcosis.

In Human Subjects: The changes in heart rate observed during electronarcosis in human subjects were similar to those noted in the dog. Application of the high initial current caused a cardiac arrest of a few seconds' duration, after which the heart started beating again, first at a low rate (fig. 4). Soon it speeded up until it reached, one to one and a half minutes after the beginning of electronarcosis, a maximum (150 to 180 beats per minute) which was considerably above the prenarcotic value. At this time the heart rate decreased again, often falling below the prenarcotic level. Three to four minutes after the beginning of electronarcosis, the heart speeded up once more until its rate reached a value of 120 to 160, which was maintained for the rest of the period of electronarcosis. Considerable variations in this general picture were observed.

Determinations of blood pressure could not be made during the period of rigidity and clonic twitches at the beginning of electronarcosis. However, since the heart was inhibited during the first few seconds of application of the current, it is likely that the blood pressure dropped immediately after application of the current, rising again with restoration of the heart action, as was the case in the dog. When, after one to one and a half minutes, it was possible to determine the blood pressure, the systolic pressure was usually near the prenarcotic level, though it often rose considerably in the following minutes. Values as high as 180 to 200 mm. were observed. The subsequent course was variable; the systolic pressure often slowly declined to, or stayed at, a level of 120 to 140 mm. (fig. 4). In some cases the systolic pressure fell even below the prenarcotic value. A rise in pressure in the further course of electronarcosis was observed on some occasions. The diastolic pressure usually followed the same trend as the systolic pressure, but the changes often were less pronounced. In some cases, during the latter part of electronarcosis a considerable drop in the diastolic pressure was observed which was not accompanied by a parallel decrease of the systolic pressure.

In 2 cases the initial inhibition of the heart lasted longer than the usual few seconds. Termination of the current after twenty and thirty seconds respectively resulted in immediate resumption of cardiac function. In a third case an arrest of the heart lasting about twenty seconds occurred about one and a half minutes after the beginning of electronarcosis. Here, again, the heart action was restored as soon as the current was cut. No difficulties were encountered in these patients during subsequent applications of current.

Electrocardiograms were taken before and immediately after electronarcosis and two days later. The electrocardiograms taken immediately after electronarcosis showed slight flattening of the T wave in lead III. This had disappeared in all cases in the electrocardiograms taken two days after electronarcosis.

Chemical and Morphologic Changes in the Blood of Dogs.—Blood Sugar: It was found that the level of the blood sugar often more than doubled during electronarcosis (table 1). An increase in the blood sugar has also been reported after electric shock treatment (Kalinowsky and others [23]). Since both during electric shock and during the initial stages of electronarcosis a certain amount of asphyxia is present, the possibility has been considered that this asphyxia is responsible for the increase of the blood sugar. This possibility was investigated in a series of experiments on a tracheotomized dog in which artificial respiration was applied from the beginning of electronarcosis.[24] Nonetheless, the same rise in the level of the blood sugar was observed even when the initial cardiac arrest, which might cause a short interruption of the oxygenation of the brain, had been prevented by administration of a suitable amount of atropine. It is therefore likely that the increase in the blood sugar is a manifestation of stimulation of the sympathetic system, which also causes the rise in blood pressure during the early stages of electronarcosis.

TABLE 1.—*Changes in Blood Sugar Associated with Electronarcosis*

Dog No.	Date	Blood Sugar Before Electronarcosis, Mg./100 Cc.	Time Second Sample Was Taken, Min.	Blood Sugar During Electronarcosis, Mg./100 Cc.
1	9/24	76	13	223
2	10/ 1	97	12	198
3	10/ 1	79	11	171
4a	9/24	80	11	195
4b	9/30	85	18	236
5	9/24	92	12	221
6	9/24	98	12	264
7a	10/ 6	106	10	225
7b	11/ 3	120	12	202
7c	11/ 7	87	12	204
7d	11/10	94	10	224
8	9/24	81	13	125

Blood Count: The number of red and white corpuscles increased materially during electro-

23. Kalinowsky, L. B.; Barrera, S. E., and Horwitz, W. A.: The "Petit Mal" Response in Electric Shock Therapy, Am. J. Psychiat. **98**:708, 1942.

24. With an intact animal such a study is impossible because of spasm of the glottis.

narcosis (table 2). Such an increase in the blood count may be produced in two ways: Either corpuscles are added to the blood, or water is removed from the plasma. It is unlikely that the latter mechanism is exclusively responsible since the red and white corpuscles usually do not increase in the same proportion. To investigate the possibility of dehydration of the plasma, the dry weights of the serum before and during electronarcosis were determined. A slight increase of the dry weight (0.4 to 6.5 per cent) was found. However, this change was insufficient to explain the large increase in the number of red and white corpuscles noted in most experiments. There must be still another mechanism active during electronarcosis. The strong sympathetic excitation at the beginning of electronarcosis may cause the contraction of blood reservoirs, such as the spleen, so that corpuscles are added to the circulating blood.

Carbon Dioxide–Combining Power: Finally, the carbon dioxide–combining power of blood was determined before and during electronarcosis (table 3). During electronarcosis a definite decrease in this value was found, which may have been due to a release of lactic acid from the muscles during the strong initial contractions.

All chemical and morphologic changes in the blood were found to be reversible in a few hours.

TABLE 2.—*Changes in the Blood Count Associated with Electronarcosis*

Dog No.	Date	Red and White Blood Cell Count Before Narcosis	Time Second Sample Was Taken, Min.	Red and White Blood Cell Count During Narcosis	Percentage Change	Dry Weight of Plasma Before Electronarcosis, %	Dry Weight of Plasma During Narcosis, %	Percentage Change in Dry Weight
1	10/12	6,290,000	13	7,120,000	13	....	....	...
		17,200		19,050	11			
2	10/13	6,630,000	10	6,850,000	3	8.29	8.32	0.4
		11,700		17,050	46			
3a	10/12	7,160,000	20	8,205,000	15	....	....	...
		24,500		28,000	14			
3b	10/18	6,490,000	15	8,180,000	26	7.86	8.37	6.5
		11,550		17,150	48			
4	10/16	8,970,000	20	9,260,000	3	8.34	8.78	5.3
		24,600		30,750	25			

TABLE 3.—*Change in Carbon Dioxide-Combining Power Associated with Electronarcosis*

Dog No.	Date	Before Narcosis, Vol. %	Time Second Sample Was Taken, Min.	During Narcosis, Vol. %
1	12/ 1	50.3	12	29.1
2	12/ 3	52.9	13	32.0
3	11/21	57.7	15	53.3
4	11/18	44.8	15	33.8

COMMENT

Electronarcosis in man, induced in the way described here, differs in some respects from electronarcosis produced in dogs. Whereas in the latter the symptoms of electronarcosis may range from a quiet narcotic to a violently hyperkinetic form, electronarcosis in man is never of the absolutely quiet or the violently hyperkinetic type. There are always hyperkinetic symptoms, which, however, never reach high intensity. As time goes on, electronarcosis in man becomes lighter; the patient becomes increasingly restive, and the appearance of intentional movements indicates the return of function of the cerebral cortex. The appearance of these symptoms can be postponed by a suitable increase in the narcosis-producing current, but they cannot be prevented. In the dog the narcotic form of electronarcosis can be prolonged indefinitely by a moderate increase in the current.

These differences in electronarcosis as induced in man and in dogs may be due to differences in structure and functional properties of the brain of the two species; it is equally possible, however, that differences in the experimental methods are responsible. From the animal experiments it is known that both factors are of importance. In some dogs the hyperkinetic type of electronarcosis will occur regardless of the method of application of current. On the other hand, some methods of applying the current favor the narcotic and others the hyperkinetic type of electronarcosis. For instance, a low initial current is likely to bring out more hyperkinetic symptoms, whereas a high initial current tends to shift the symptoms toward the narcotic form.

In the present observations on patients the initial current has always been low, and this may have prevented the development of a strictly narcotic form of electronarcosis in man. Only further experiments with higher initial currents

can decide whether the structure of the human brain or the method of application of current is responsible for the failure to produce the narcotic form of electronarcosis in man. On the other hand, the absence of violently hyperkinetic symptoms may well be caused by our practice of terminating electronarcosis when the patient becomes too restive, so that the hyperkinetic symptoms are not given time to develop fully.

The initial symptoms of electronarcosis resemble those of electric shock. Slight differences can be found, however. The hypotonic period between the initial flexion and the development of extensor rigidity is relatively long (up to twenty to thirty seconds) in electric shock but is quite short, or even absent, in electronarcosis in human subjects. Whereas in electric shock extensor rigidity is self limited, in electronarcosis this symptom lasts until the decrease of the initial current. Self-limited clonic twitches are observed in both conditions. In both states respiration starts after about the same interval provided that the current has been sufficiently decreased to make return of respiration possible. The differences between the symptoms of electric shock and those observed in the beginning of electronarcosis are most probably due to the differences in application of the current; in production of electric shock a strong current passes for a fraction of a second only, whereas in induction of electronarcosis a weaker current is applied for thirty seconds.

Electric shock therapy, when carefully applied, is a safe procedure. Since, as judged from the symptoms, the initial stages of electronarcosis can be considered as a modified electric shock, it is likely that the beginning of electronarcosis is equally safe. Indeed, in the great majority of electronarcoses respiration was established within a reasonably safe period, and in most cases in which the level of electronarcosis was too high a slight decrease in the current immediately restored adequate respiration. On the few occasions in which respiration did not respond sufficiently on decrease of current, it was quickly restored by turning off the current. The cardiac arrest immediately after application of current was usually not more than a few seconds. Whenever the heart action was suspended for more than the usual period, the beat was restored promptly by turning off the current. After the initial period respiration could be easily controlled. Insufficient oxygenation of the body, as indicated by strained respiration and developing cyanosis, could be corrected by a slight decrease of the current. Undue changes in the circulatory apparatus during the later part of electronarcosis, such as the development of a high blood pressure or a rapid heart rate, have been found to be immediately reversible by turning off the current. All patients with obvious disease of the heart and vessels were excluded. Besides, the circulatory apparatus was carefully watched during the series of applications of current. Electrocardiographic examinations were made at regular intervals. In none of the patients were any undue effects on the circulatory apparatus observed.

None of the patients had fractures or dislocations of the spinal column. This is probably because clonic twitches, and perhaps extensor rigidity, during electronarcosis are less pronounced than during electric shock.

It can be concluded that induction of electronarcosis, like that of electric shock, when carefully carried out, is reasonably safe. Indeed, more than 100 electronarcoses have been induced in human subjects without any serious involvement. Since all methods for induction of shock thus far employed in the treatment of mental disorders are purely empiric, it is premature to speculate on the therapeutic value of electronarcosis. Although no claim for the curative properties of electronarcosis is made at present, the method offers for trial a clinically feasible procedure.

SUMMARY

1. In man, as in animals, a state of unconsciousness (electronarcosis) can be maintained by the passage of a current through the head. In man electronarcosis has been prolonged up to thirty minutes.

2. Two forms of electronarcosis have been observed in the dog—a narcotic form, which resembles chemical narcosis, and a hyperkinetic form, which is characterized by strong motor activity.

3. In man the symptoms of electronarcosis were a mixture of symptoms of the narcotic and the hyperkinetic type of electronarcosis.

4. All symptoms studied, occurring during and after electronarcosis, were found to be completely reversible.

Dr. A. J. Rosanoff, Dr. G. M. Webster, Dr. M. S. Plesset, Dr. R. J. Gladen and Dr. C. H. Ellis cooperated in various phases of this investigation.

California Institute of Technology.
Patton State Hospital.

DISINTEGRATION AND RESTORATION OF OPTIC RECOGNITION IN VISUAL AGNOSIA

ANALYSIS OF A CASE

ALEXANDRA ADLER, M.D.
BOSTON

The complexity of the process of optic recognition is such that no two patients suffering from the disorder called visual agnosia have identical derangements in function. An analysis of the symptoms and their changes in the course of recovery in a young and cooperative patient appeared worthy of record for the further light such a study may shed on the process of visual perception.

REPORT OF CASE

H. C., aged 22, married, had been a guest at the Cocoanut Grove night club, Boston, on Nov. 28, 1942, the night it was destroyed by fire, with 491 patrons killed and many more injured. She was one of the 132 patients admitted to the Boston City Hospital during this night. On entry she had only small, superficial burns over the right scapula. It was immediately noticed that "she could not see." She was hoarse for almost two weeks, during which tracheal inflammation led to moderate difficulties in breathing, and for five days she had minimal rales in her lungs. From December 2 to December 9 sulfadiazine was given, the total dose being 42 grains (2.73 Gm.). She coughed and expectorated thin, white sputum during the first five days. She talked almost incessantly during the first two weeks. Her talk was incoherent, but with clear enunciation of words. There was marked reiteration. She kept repeating during the first two days, "May I move my arm? May I move my leg? May I move my head?" When she was told that she could move, she said, "Oh, good," and then did so. Several times she complained that she could not see. She had to be fed, since she could not find her food, but she identified it by its taste. After two days she recognized nurses as such "by their white uniforms," as she explained at that time. For long periods she gazed stonily ahead as if she did not see anything, but she listened attentively to voices in her vicinity and showed pronounced echolalia in response to questions during the first week. For instance, when she was asked, "Helen, what do I hold in my hand?" she would reply, "What is in my hand; what is in my hand; what is in my hand, Helen; what is in my hand?" She was unable to name objects shown to her, and her gaze did not fix on them during the first week. However, she quickly identified people by their voices and objects, like keys, by their sound. Neurologic examination revealed an equivocal plantar response on the right; this became normal during subsequent testing. She was disoriented for time and was unable to give the date of her marriage. She knew her own and her husband's name but at first could not give her address. She was unable to do simple calculations and could not read. She could write, however, although at first with perseveration and errors. During the first days she did not know that she had been in a fire, but after this had been impressed on her several times, she kept repeating all through the first week, without any adequate emotion, that there had been a fire at the Cocoanut Grove, that many people had been killed and that she did not know how she got out. Her husband, who had been with her on that evening, stated that he had seen a sheet of flame coming toward him. He grabbed his wife and started toward an exit. When they reached the door the flames overtook them. He lost consciousness and woke up in the hospital. He was hoarse for one week but, except for superficial burns over his face, presented no other signs.

The patient had completed high school and business school and had worked as a comptometer operator for a large firm for one year, until her marriage in August 1942. Her parents were of Italian origin. The family's and the patient's histories previous to the injury were without significance.

Three months after her injury the patient gave the following account of the first days of her illness: "The last thing that I remember of that night at the Cocoanut Grove is that suddenly everything became black. My husband started pulling me out. The next thing I remember is the Boston City Hospital, but I do not remember anything about the first few days. At first everything seemed dark to me. Then I could see white—nurses and doctors. I recognized them by their uniforms, and I could distinguish the doctors because of the odor of tobacco. Soon I could distinguish doctors from nurses by the way their hair was done. Doctors do not have curls. The voices helped a lot. I talked so much because I felt like two people in one, saying something different from what I wanted to say. I know that I repeated a lot because I felt that I had not said it correctly. I could not breathe during the first days. At first I thought I was at home because my sister was with me. When I saw nurses I knew I was in a hospital."

I saw the patient for the first time five days after her injury and from then on daily during her stay in the hospital. The patient was at first totally blind and then, after two days, could distinguish white from dark but could not recognize colors. In the beginning she could not recognize letters or words but could write, thus exhibiting the picture of a pure (subcortical) visual alexia, Wernicke's type. She had visual agnosia for objects, pictures and persons. There was complete acalculia. During the first two weeks she presented a picture of psychomotor excitement, flight of ideas, reiteration in her activities and in her flow of talk, echolalia and perseveration in her writing. Hearing, smell, taste, touch, articulation and understanding of words and motor ability were not impaired. A diagnosis of lesion of the brain, probably caused by carbon monoxide fumes, was made.

She was discharged from the hospital on Dec. 23, 1942, and since then she has been seen at weekly intervals.

From the Department of Neurology, Harvard Medical School, and the Neurological Unit, Boston City Hospital.

COLOR AGNOSIA

As has already been mentioned, the patient recognized white after the second day of her illness. After two weeks she recognized all colors. In the interval she frequently made mistakes in trying to identify red and green but never erred in the recognition of blue and yellow

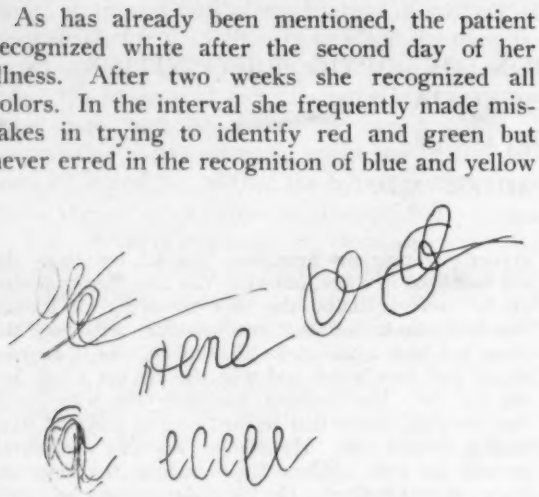


Fig. 1.—The patient was asked to write an *e*, "Helen" and an *o* (December 4). Below, she was asked to write an *a* and an *e* (December 8).

once it had come back to her. However, up to the time of this report, seven months after the injury, she frequently called a dark blue "purple." After the first two weeks she was able to name correctly the color which corresponded to various objects or the objects which corresponded to colors and could match various shades of the same color. She was also able to match colors according to their intensity.

There is general agreement that the lesions of the brain associated with color agnosia are in the ventral parts of area 18 (Nielsen and FitzGibbon,[1] Poetzl[2]). It is assumed that the lesion is bilateral when function does not return and that it is unilateral when function does return.

WRITING

From the beginning the patient was able to write, but she did so with perseveration and errors (fig. 1). This condition prevailed during the first two weeks, after which her writing improved. Four weeks after her admission her writing was similar to that before her illness except for some difficulty in her keeping to the line and occasional skipping of words. Figure 2 allows comparison of her writing shortly after her admission with a sample obtained later. She could not copy, however, a feature typical of the optic type of alexia.

Her spatial disorientation expressed itself in the way in which she dealt with single cardboard letters when asked to put them together to form a word. For instance, five months after the injury, she formed the word "Tracy" in the following way: "Lrɐɔy" When attention was called to her mistakes, she corrected them with difficulty. By the end of the sixth month she no longer made the mistake of inverting the cardboard letters, and she remarked that she was taking particular care to set the letters in the right direction.

An interesting phenomenon could be observed, however, after several months had elapsed. She had to think for some time before she could write certain letters and started to confuse some of them. For example, six months after the injury, when asked to write a small *t*, she wrote a small *i*. This was the way in which she often perceived the small *t* when reading. Evidently her impaired visual perception finally changed her writing. In addition, she forgot how to write some of the less common letters, such as small *q*, and noticed herself that she forgot or confused letters when she had not used them for some time.

The patient had been an expert touch typist before her illness, and when she was asked to type, a few months after her admission, she proved herself able to do so rapidly, although she made occasional mistakes. Her mistakes consisted of confusing letters which were similar in appearance, such as small *t* and small *l*. Thus, her impaired perception and imagery interfered in the same way with her typing as it did with her writing.

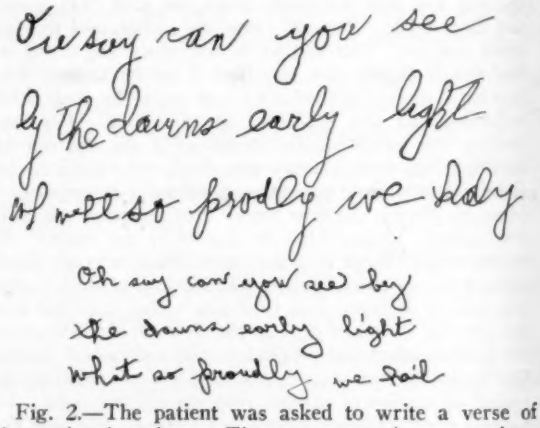


Fig. 2.—The patient was asked to write a verse of the national anthem. The upper sample was written on Dec. 17, 1942; the lower sample, on May 4, 1943.

PURE VISUAL ALEXIA

Impairment in Reading of Mathematical Figures.—During the second week of her illness the patient started to use her index finger to trace the contour of objects. This kind of procedure has been observed in agnostic patients

1. Nielsen, J. M., and FitzGibbon, J. P.: Agnosia, Apraxia, Aphasia, Los Angeles, Los Angeles Neurological Society, 1936.
2. Poetzl, O.: Die optisch-agnostischen Störungen, Leipzig, F. Deuticke, 1928.

by Westphal,[3] Goldstein and Gelb,[4] Nielsen and FitzGibbon [1] and others. With the normal person, too, the visual impression is made more vivid if he traces the object with the finger. He is less likely to overlook details. Furthermore, tracing aids perception by successive addition of parts instead of recognition by simultaneous perception of the parts of the whole. As will be shown later, recognition by addition has become the patient's way of dealing with optic problems.

Whereas the patient was not able to recognize any letter during the first two weeks, she occasionally succeeded in recognizing mathematical figures. While she did not recognize the figures 2, 3, 5, 6, 8 and 9, naming them interchangeably 6 or 5, she recognized the 1, 4 and 7 during the second week of her illness. The recognition first of figures with straight lines and later of those with curves is of special interest. Closer examination of this phenomenon revealed a fundamental disturbance of visual recognition: The patient perceived only parts and guessed the rest. Since it is possible to guess where a straight line is going but not the direction of a curve, she was able to recognize the figures 1, 4 and 7 first. The first number with a curve that she recognized was 5. This she recognized by the combination of the upper two straight lines. At present, seven months after injury, she correctly recognizes any single number. She is conscious of the fact that she distinguishes the single numbers by their special characteristics. A few months ago she explained: "In a 6 there is only a lower loop. If I find an upper loop, too, I know it is a 3. If there is only an upper loop, it is a 9. There are two circles in the 8." But since she recognizes objects by tracing the contours, by adding the parts and by making conclusions from all she has perceived, she has to take more time than does the normal person, who recognizes all the parts, in the main, simultaneously. Her disturbance can be analyzed more closely by tachistoscopic procedures. The following protocol was taken two months after her admission: An 18 was shown to her. She recognized the 1 correctly on exposure for one hundred-fiftieth of a second, but she recognized the 8 only on exposure for one-fiftieth second. The following protocol reveals how she finally recognized the 8:

1/150 second.... "A 6?" She then corrected, saying, "A 3. I first thought the loops were in different directions. Or is it a 5?" When asked to draw what she had seen, she wrote ɔ̄, a 5 without the vertical line.

1/100 second.... "A 6."

1/50 second.... "Oh, it is an 8. All the time I have seen only the lower loop, and therefore I thought it was a 6."

It has been pointed out that numbers were the only symbols that could be recognized by some agnostic patients or that numbers were the first symbols they recognized during recovery. The way in which this patient went about it explains why it is easier for agnostic patients to recognize numbers than letters. There are only ten numbers, and it is comparatively easy to distinguish them by a few characteristics. If the patient did not know whether a number or a letter was shown her, recognition was more difficult, or even impossible. Therefore she always asked first, "Is this a number or a letter?" She herself, remarked during the second month: "I have to think to find out what it is." Head [5] cited a patient who made a similar remark: "I have to reason out the meaning of the whole picture."

Impairment in Reading of Letters and Words.—The patient is still unable to read what she herself has written. When she is asked to point out a certain word in a sentence which she has just finished writing, she counts out the words one by one to get to the word requested. During the first two weeks of her illness she could not recognize any letter, whereas at present she recognizes all printed capitals when presented singly and most of the printed letters from the small alphabet. Of the written alphabet she recognized on last examination, six months after injury, only about half the capitals and half the small letters. As it was with figures, she recognized letters with straight lines first, the first letter to be recognized being the *H*. This she recognized with joy nineteen days after her injury and said, "Because my name is Helen." On the same day she called *K* a "capital *I*." Here she perceived the first straight line only and, on request that she draw what she had seen, made the one straight line of the *I*. The following day, December 17, she confused *P, B* and *R* as such, and she still does so occasionally. She remarked in March 1943, "Capital *P, B,* and *R* look alike to me." Her confusion is derived from her procedure of tracing first the left upper part, which is alike in these three letters. Another difficulty which still persists is her confusing of *F* with *E*, which, again, is explained by the similarity of the upper left part in the two letters. She experiences the greatest difficulties with written letters, all of which exhibit curves. All the letters of the written alphabet were exposed singly, not alphabetically, first the capitals and

3. Westphal, A.: Aphasie, Ztschr. f. Ethnol. **6**:94-102, 1874.

4. Goldstein, K., and Gelb, A.: Psychologische Analyse hirnpathologischer Fälle, Leipzig, J. A. Barth, 1920, vol. 1, pp. 1-143.

5. Head, H.: Aphasia and Kindred Disorders of Speech, Brain **43**:87-165, 1920.

then the small letters, and the patient was asked to read aloud and then to copy the letters as she had seen them. Her errors were as follows: 1. She perceived only parts (fig. 3 *A*). 2. She added to the parts which she had perceived by guessing at the completion (fig. 3 *B*). 3. In some instances she left out *and* added, as in *i* and *j* (fig. 3 *C*). 4. Occasionally she showed a tendency toward mirror writing (fig. 3 *D*). 5. Whenever the patient recognized a letter, she "copied" it in her own handwriting (fig. 3 *E*). These errors are fundamentally the same as those initially encountered when she was dealing with numbers.

Five months after her injury, small pieces of cardboard, each containing a single letter, were

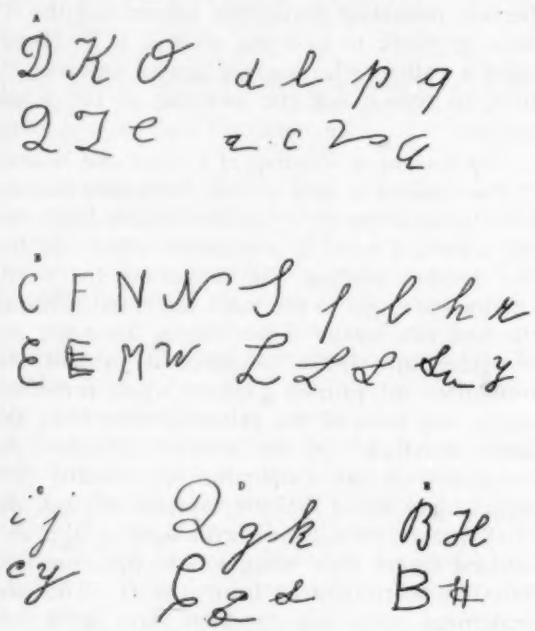


Fig. 3.—The patient was asked to read samples (upper line) and then to copy the letters (lower line) as she saw them. She left out parts (*A*), added parts (*B*), left out and added parts (*C*), showed mirror writing (*D*) and "copied" recognized letters in her own handwriting (*E*). Date: March 2, 1943.

shown to her. She recognized the *e*, "because it has a space on this side," as she said, pointing to the right. Then the same *e* was presented to her upside down. "That is a small a because the space is on the other side," she said, pointing to the left. To the normal person an *e* presented upside down still does not suggest an a, regardless of the open space on the left, but since the patient had by then learned to recognize letters by their outstanding characteristics, her error is understandable. During the same experiment she immediately recognized the *t* as such. When it was presented upside down, she named it with conviction "small *f*." She explained that she had recognized it by the hook on top and the horizontal line. Her spatial disorientation prevented her from noticing that the hook went to the opposite side and that the horizontal line was lower than it is in an *f*.

The first word that she recognized was her name "Helen" which she did the day she recognized *H*. At that time she could not recognize any of the remaining letters of her name when they were presented singly. This shows that she had guessed her name after recognizing the *H*. This process of guessing the whole word from a few letters, aided by an estimation of the length of the word, is a procedure which she has followed ever since. This, however, results in her succeeding with printed words only, since she can hardly make out enough written letters to guess a written word. In several instances it has been reported as surprising that certain patients could read some long words correctly but persistently erred with short words. Short words can easily be changed by reversal of only one or two letters, which is impossible in long words. This explains the phenomenon which this patient presents, too. For instance, she read "GIRL" as "GOING" (fourth week after injury), having first recognized the *G* and the *I*. In the second month after injury, when shown the word "PRESIDENT" and asked to copy it as she saw it, she wrote "PRESDEWT," skipping the *I* and adding V to the N. But after a few seconds she remarked that this word probably meant "president."

The patient frequently reads a word from the line above as belonging to the lower line, regardless of whether or not she has previously recognized the word. She is never confused by a word from the line below. This tendency to fix her optic attention at some place and revert to it subsequently was present from the beginning of her illness. This is shown in the following protocol, taken three weeks after injury, when the symbols were presented to her successively, one below the other:

"What is this?" [9] ..... "Capital A"
"What is this?" [8] ..... "9"
"What is this?" [B] ..... "8"
"What is this?" [W] ..... "Capital B"

This protocol looks almost as if the patient were a malingerer who named previously shown samples instead of those presented to her at the time of identification. But when the patient, after having named the previously presented symbol, was asked to show where she had seen this, she pointed, after some hesitation, to the correct line, above. Analogous observations were made by

von Stauffenberg [6] and by Heidenhain,[7] who reported that their agnostic patients gave the name of an object which they had not recognized as their response to a different object during subsequent examination. Such perseveration may at times give the impression of preoccupation with background, as in copying of block designs and in other optic performances, when, in fact, the error results from the "background" being first seen with subsequent perseveration of the impression. Preceding optic impressions interfere with the subsequent ones, a "disturbance of figure-ground relationship" (Goldstein and Gelb [4]) being thus simulated. This adherence to a previous optic impression seems to be analogous to perseveration of speech or writing in patients with lesions of the brain. Similarly, it was possible to trace the interference of antecedent visual impressions on other optic performances, such as her drawing and reading.

In several cases of optic agnosia, in which the reading disability was carefully examined, reactions analogous to those of this patient (Goldstein and Gelb,[4] Scheller and Seidemann [8]) were reported. There are cases on record of a patient's inability to relax visual fixation (Bálint,[9] Holmes [10]) without evidence of agnosia. Therefore it appears that inability to comprehend the whole in cases of agnosia is more important than, and is independent of, the patient's perseveration of optic fixation on some detail.

A sample of the patient's reading of a text [11] printed in medium-sized letters follows. The original text is given above and the patient's reading below, in quotes. The sample was obtained six months after injury.

The contents of this book center around activities of children.
"The alphabet to—of this book center around activities of children."
both at work and at
"both of work and at"
play.
[The patient skipped over this line—a frequent happening.]
It includes animals and toys as well.
"If children act and ways would."

The patient, therefore, is subject to the following errors: 1. In contrast to the way in which normal people read, she does not recognize the word as a whole but adds up letters which she has recognized. The rest of the word may be guessed correctly or incorrectly. If she is unable to guess a word, she is frequently not able to make it out, even if she has finally recognized all the letters, because of the spelling of the English language, which is not phonetic. 2. She skips over words. 3. She leaves out lines.

She herself remarked that since her illness letters looked different to her. "They look as if they were all together, as if it were just one line. I have to separate them myself." The smallest print was most difficult for her to read because she easily slipped into surrounding letters. Larger interspaces prevented this. Therefore even if the patient had been unable to make out any letter in a word, she was occasionally able to recognize each of them if they were uncovered one by one.

The patient was able to identify by touch, without difficulty, letters cut out of cardboard. It was therefore only a disturbance of optic recognition which interfered with her reading.

The patient had never been able to read music. Therefore no change in this ability could be found in her. It may be assumed that she would not be able to read music at all, since she would not be able to perceive its spatial arrangement correctly. Such a disturbance has been described in a few suitable agnostic patients (Henschen,[12] Poetzl [2]). On the other hand, she quickly identified any popular tune by ear, even during the first week of her illness.

Impairment in Copying of Letters and Words.—Her reading difficulties are graphically registered by the way in which she copies letters or words. Her errors in copying single letters have been shown in figure 3. The difficulty increases notably when she copies two or more written letters or a word (fig. 4 *A*). The figure shows how little, if any, improvement there is in her ability to copy handwriting.

GEOMETRIC OPTIC AGNOSIA

Impairment in Copying of Geometric Figures and Patterns.—During the first month of her disease the patient was unable to recognize simple geometric figures. For instance, a protocol from the fourth week contains the following sample:

"What is this?" [a circle] "Looks like an alphabetical *A*."
"What is this?" [a triangle] "Looks like a great, big *A*."
"What is this?" [a square] "Looks like a capital *B*."

Five weeks after injury she again called an equilateral triangle "a big *A*." When she was

6. von Stauffenberg, W.: Ueber Seelenblindheit, Arb. a. d. hirnanat. Inst. in Zürich **8**:1-212, 1914.

7. Heidenhain, A.: Beitrag zur Kenntnis der Seelenblindheit, Monatschr. f. Psychiat. u. Neurol. **66**:61-116, 1927.

8. Scheller, H., and Seidemann, H.: Zur Frage der optisch-räumlichen Agnosie, Monatschr. f. Psychiat. u. Neurol. **81**:97-189, 1931.

9. Bálint, R.: Seelenlähmung des "Schauens," Monatschr. f. Psychiat. u. Neurol. **25**:51-81, 1909.

10. Holmes, G.: Cerebral Integration of Ocular Movements, Brit. M. J. **2**:107-112, 1938.

11. Mabie, P.: First Steps to Reading, Poughkeepsie, N. Y., Artists and Writers Guild, Inc., 1939.

12. Henschen, S. E.: Klinische und anatomische Beiträge zur Pathologie des Gehirns, Stockholm, Almquist & Wiksell, 1922, vols. 5-8.

told that it was not a letter, she recognized the triangle. She had seen the outline of the triangle and, in anticipation of a letter, had made the wrong conclusion. Evidently the compensating mechanism for her difficulty in optic recognition was guessing. Up to the present she has not gone far beyond recognition of the simplest geometric forms. After six weeks she correctly copied a triangle, a square and a circle, but up to the present she cannot copy a hexagon (fig. 4 *B*). The situation becomes even more confusing when she tries to copy figures with curved lines. The tachistoscope gives additional information about the difference between the normal person's and the patient's way of optic recognition (fig. 4 *C*). Figure 4 *C*, *a* which normally is correctly perceived at one hundred-fiftieth second, was shown to the patient at a gradually increased time of exposure, and the patient was asked to draw what she had seen. The protocol shows the patient's inability to perceive details simultaneously, as is normally done when one sees simple figures. The patient perceived only parts and, by gradually tracing around the contour, added up the parts. In all such instances she started with the upper part of the figure, and usually with the left corner. Evidently this sequence followed the pattern of the writing movement. At the end of the experiment (fig. 4 *C*), when, at an exposure time of five seconds, she had recognized all details, the patient said, "I could not get all the little marks first because it was so fast. I only got the two upper ones first."

With unlimited time of exposure too, the patient was unable to perceive the whole (fig.

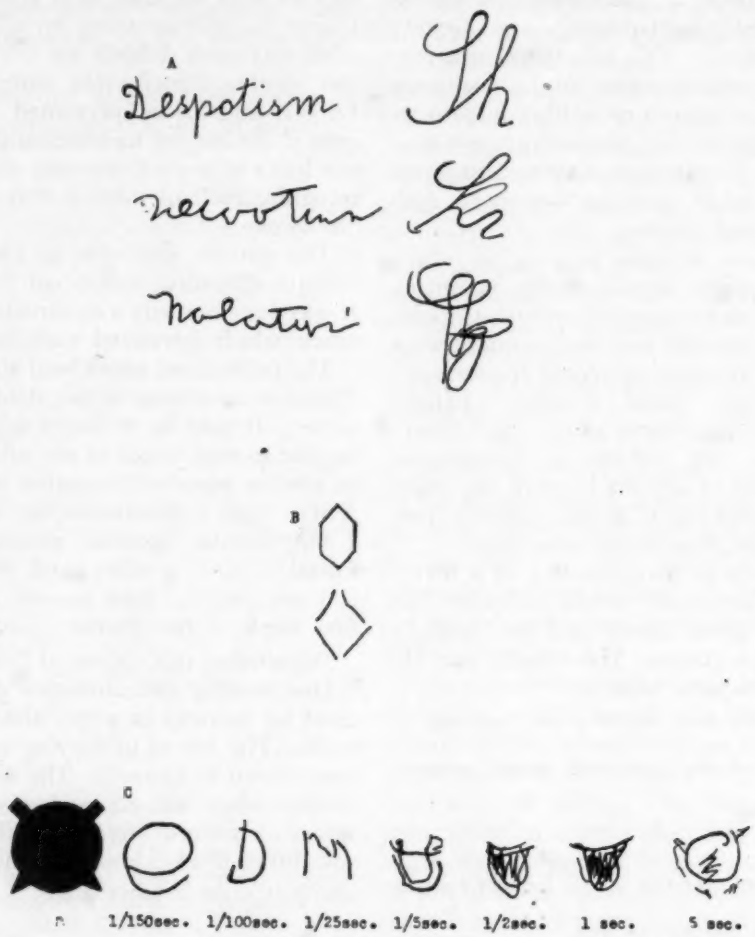


Fig. 4.—(*A*) Attempts to copy the same sample (uppper line) at different times, the middle line on May 27, 1943 and the lower line on Feb. 1, 1943. Hardly any improvement is apparent.

(*B*) Attempt to copy a hexagon (at the top). As usual, the patient first copies the upper and then the lower parts. Date: May 4, 1943.

(*C*) On tachistoscopic exposure of *a*, which normally is correctly recognized at one hundred-fiftieth second, the patient drew first the upper two marks (one twenty-fifth second), then perceived the lower contour (one-fifth second), then filled in the contour (one-half second). Finally, at five seconds she perceived all the details. Date: March 2, 1943.

5 *A*). She perceived the figure as being divided into parts, except for figure 5 *E*, which she copied approximately correctly, saying, "That reminds me of the United States, a capital *U*." When no straight line was drawn through the

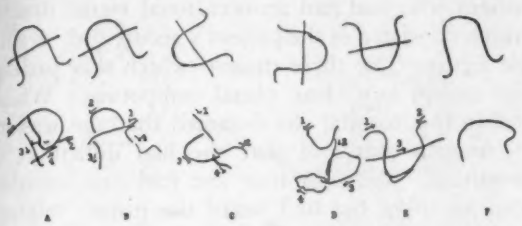


Fig. 5.—In the lower line, the patient tried to copy (*A* and *F*) and to trace through transparent paper (*B*, *C*. *D* and *E*) the figures at the top. As usual, she started at the upper left corner, or occasionally picked out the straight line first (*B*). Date: May 4, 1943.

curve, the patient was able to copy, as well as to trace, the curve correctly (fig. 5 *F*). Figure 6 *A* demonstrates how confusing the task became

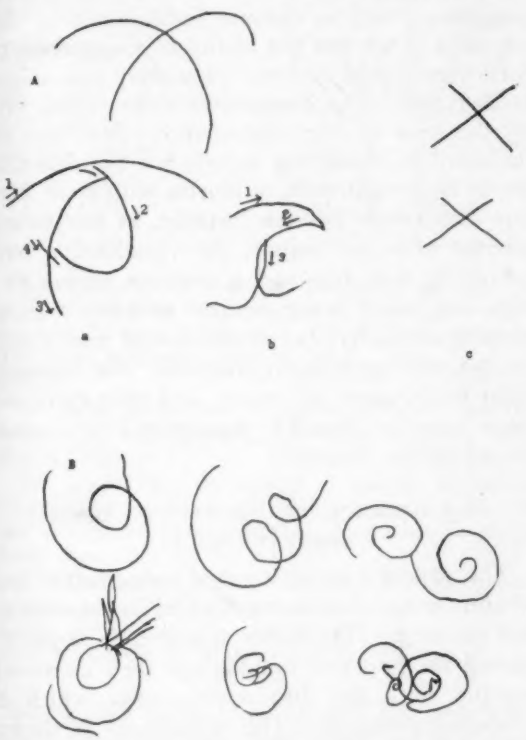


Fig. 6.—*A*, attempts to copy pattern (at top). Sequence and directions are indicated by numbers and arrows. Note disintegration of the figure on two consecutive attempts (*a* and *b*) when *c* was slightly curved. Date: April 15, 1943.

B, attempt to copy a pattern (at top). Note disintegration of the figure into several incoherent parts. Date: March 18, 1943.

when a cross was only slightly varied by curving the lines. More complicated figures made the confusion worse (fig. 6 *B*).

The patient's disturbance is strikingly evidenced by her inability to copy simple block designs. When she tried to copy a red rectangle surrounded by a white background with the Kohs blocks two months after injury (fig. 7), she started with a white block, then put a red one on its right side, lower than the white one, and then became thoroughly confused as to where to put the next one. Four months after injury she remarked, while practicing with the blocks, "The white baffles and confuses me. I always think there is something in addition," and pointed to the white background on the left of the sample. Thus she showed good insight into the so-called disturbance of figure-ground relationship. The background on the left interfered with her attention for the important figure in a way which had been noted before in her reading,

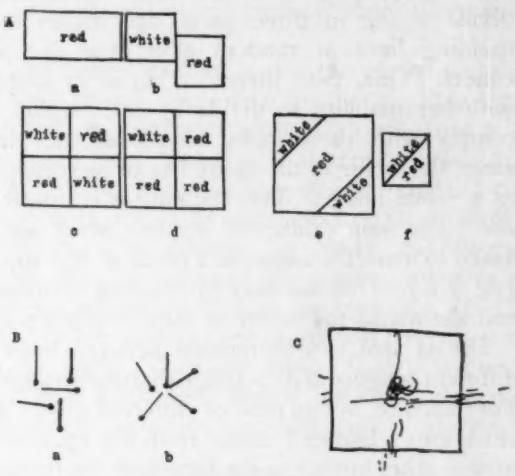


Fig. 7.—*A*, reproduction of Kohs block patterns, in which *a*. *c* and *e* are the samples and *b*, *d* and *f* are block reconstructions by the patient. Dates: Reconstruction *b* was done in January 1943, and *d* and *f* were made in May 1943.

B, pattern of matches (*a*), which the patient tried to copy (*b*). Date: May 27, 1943.

C, patient's attempt to mark the center of a square by drawing lines across and marking their crossing point. Date: Jan. 15, 1943.

when previous optic impressions interfered with subsequent ones. At present, seven months after injury, her copying of block designs has not improved much as compared with earlier attempts (fig. 7 *A*, *c*, *d*, *e* and *f*).

Agnostic patients copy patterns made of matches more easily since they can best perceive straight lines. Therefore the match test, although advocated by some authors, is more useful with apractic than with agnostic disturbances. The patient could copy simple patterns correctly but erred with more complicated ones (fig. 7 *B*).

Copying objects from life was easier for her than copying the same object from a drawing. She remarked, "Lines confuse me. If it is an object, I know which is front and which is in back."

Disturbance of Recognition of Spatial Relationships.—Although the patient was able to identify straight lines as such and to draw lines horizontally and vertically on request, she could not divide them correctly. During the first two months, when asked to divide a line in half, she traced several times along the line and marked the ends of the line over and over, sometimes somewhat beyond the original marks, before she made a dividing line. Thus she reenforced her knowledge of the length of the line by use of her proprioceptive sense. Whenever she is asked to divide a line in more than two parts, she still becomes confused. For instance, when asked to divide a line in three parts, she makes three dividing lines at random along the line and counts, "One, two, three." This is in keeping with her inability to divide by calculation. To comply with these tasks, simple as they may seem, the whole of the figure has to be registered as a visual image. This the patient is unable to do. The same difficulty applies when she is asked to mark the center of a circle or of a square (fig. 7 *C*). This she does by drawing diameters, and she marks the center at their crossing point.

She is able to differentiate between lines of different lengths and to judge distances roughly. For instance, when pins of different colors are stuck into a blotter 1 meter from her eyes, close to each other but not in the same line, the distance of each pin from her eyes being increased 1 cm., she is able to say which one is farther from her and which one nearer. She can also give a fair estimate of the length of larger objects. All this, however, implies a one dimensional procedure only, preponderantly that of addition. When she cannot apply this, she encounters difficulties. As one may expect, the patient also has difficulty in finding her way around in a new environment. When she returned home, after four weeks' stay in the hospital, she was at first unable to find her way around. During the first month she could not give any description of the streets in her immediate neighborhood, and she confused them during the following months. When she visits the hospital, where she has been many times, she still errs when taking turns in the corridors and has to look at the arrows to read directions. When she goes shopping she relies on certain marks, such as "a small white house at the corner where I have to make a turn," traffic lights and signboards.

VISUAL IMAGERY

Dreams.—It has been reported by some authors (Charcot,[13] Grünstein[14]) that their agnostic patients lost the ability to dream visually. Wilbrand[15] and Brain[16] each reported on an agnostic patient who had had an occasional visual dream which consisted of the patient's seeing only a single figure. The three dreams which this patient had lacked any clear visual component. While still in the hospital she dreamed that she was in an oxygen tent and that she had difficulty in breathing. She said that she had not actually seen anything but had heard the nurses talking to her. During her first two weeks at home she dreamed twice that she was still in the hospital, and woke up feeling relief at being at home. She does not remember having seen anything during these dreams. All this indicates that agnostic patients either have no visual dreams or that the visual component of their dreams is diminished.

Visualization and Formation of New Visual Images.—There is definite indication that this patient has not lost the ability to visualize or to form new visual images. However, this ability is defective. The impairment follows the rule of the rest of her disturbance. She has no difficulty in visualizing colors, but the difficulty grows on visualization of objects with more than one dimension. So, for instance, as late as six months after her injury, she visualized a bird as having four legs and a table as having two legs and made many similar mistakes. Occasionally, however, her formation of new visual images was surprisingly complete. For instance, eight weeks after her injury, and afterward, she gave correct, detailed descriptions of rooms visited by her recently.

DISTURBANCE OF ABILITY TO DRAW SPONTANEOUSLY

The patient's impairment of visualization and of optic imagery is exemplified by her spontaneous drawing. This ability was greatly impaired during the first two months but then improved steadily until the fifth month, after which it remained stationary. The disturbance is shown

13. Charcot, J. M.: Leçons sur les localisations dans les maladies du cerveau, Paris, V. A. Delahaye, 1882, vol. 3.

14. Grünstein, A. M.: Die Erforschung der Träume als eine Methode der topischen Diagnostik bei Grosshirnerkrankungen, Ztschr. f. d. ges. Neurol. u. Psychiat. **93**:416-420, 1924.

15. Wilbrand, H.: Ein Fall von Seelenblindheit und Hemianopsie mit Sectionsbefund, Ztschr. f. Nervenh. **2**:361-387, 1892.

16. Brain, W. R.: Visual Object-Agnosia with Special Reference to Gestalt Theory, Brain **64**:43-62, 1941.

by a comparison of four drawings of the same object made at different times. Each time she was asked to draw a girl (fig. 8). Figure 8*A* shows loss of awareness of bodily relations. On

Fig. 8.—(*A*) The "nostrils" are above the eyes and are surrounded by hair, evidence of interference of the previous drawing of the eyes. No mouth is indicated. The arms originate from the head. Date: Dec. 17, 1942.

(*B*) Two nostrils are drawn on the left, "one for each nostril"; the mouth (*1*) is below the chin. Date: Jan. 4, 1943.

(*C*) In drawing the nipples (*1* and *2*) the patient placed the right nipple (*2*) within the right arm. At last the patient was asked to draw the navel (*3*). Date: Jan. 25, 1943.

(*D*) No significant change from this drawing occurred subsequently. Fingers were not drawn at first. When asked to put them in, the patient did so, counting them out carefully. Date: April 15, 1943.

making the short lines around the "nostrils," she commented, that some people had hair about their nostrils. Immediately preceding this she had drawn the "eyes" without any eyelashes or eyebrows. This represents the same kind of interference of a previous optic performance on the subsequent one that had been encountered in her reading and in her block reconstructions—an optic perseveration, which may be misinterpreted as a "disturbance of figure-ground relationship." In figure 8*C* a variation is made by addition of a "hat." She said, "That makes it easier to draw the hair," but the drawing looks as if the hat was transparent. When asked to put the nipples in, she put the right one within the right arm (fig. 8*C*, *2*). She knew where to locate the nipples on her own body and had not intended to place a nipple on the arm, but she misinterpreted the right arm, although drawn by her a few minutes earlier, as a part of the trunk. After the fifth month her ability to draw a girl remained stationary (fig. 8*D*).

Immediately after the patient had marked the navel (*3*) in figure 8*C*, she was asked to draw a house (fig. 9). The resemblance to the drawing of a girl (fig. 8*C*) is striking. At last she put in the "entrance" (fig. 9, *1*) and said, "The door is too high up. One would not be able to get in. I was thinking of the girl . . . the navel." Thus the patient showed considerable insight into her disturbance, which caused an interference of previous optic performance with subsequent ones.

The patient is able to locate correctly touch or pain stimuli applied to her body. This corresponds to her intact senses of touch, pain and proprioception. But she is unable to mark the location of the stimulus correctly on a chart of the body, since she lacks optic recognition of bodily relations. For instance, a circle was drawn which was to represent the contour of a face, and she was asked to draw the eyes (fig. 10*A*). She made first one in the center and then another on the right. Then she said, "That is wrong." She then made lines across the circle in order "to judge distances," as she said, and finally

Fig. 9.—Drawing of a house, made immediately after that of a girl (fig. 8*C*), the influence of which is striking in this sketch. The entrance (*1*) was placed above the ground, and the patient, noticing the mistake, explained that she was thinking of the navel (*3*) of the girl in figure 8*C*. Date: Jan. 25, 1943.

marked another eye on the left. When asked to draw the mouth, she marked two symmetric ones. The aforementioned errors indicate disintegra-

tion of awareness of spatial relations. Similar examples have been given by von Stauffenberg,[6] Engerth [17] and others. Such a disturbance in agnostic patients was named "constructional apraxia" by Kleist,[18] who defined it as a failure of spatial construction without apraxia of movement. But it seems misleading to call a disturbance which is so closely related to visual disorder "apraxia." The same holds true for the term "optic apraxia," which Poppelreuter [19] used for the disturbance of drawing in optic-agnostic patients.

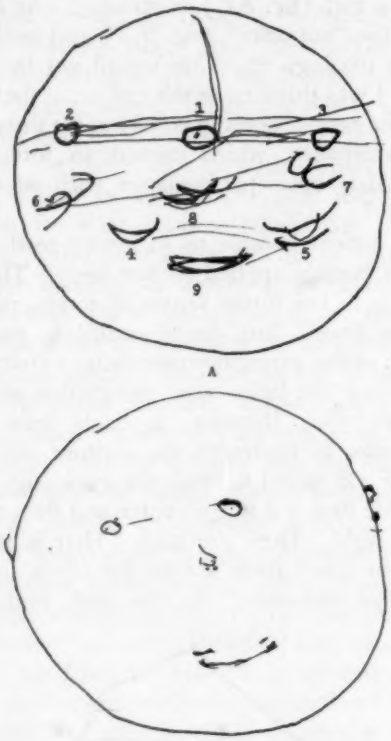


Fig. 10.—(*A*) The patient was asked to mark the eyes (*1, 2* and *3*) in the circle and then to mark the mouth (*4* and *5*). Noticing her error, she marked two ears on each side (*6* and *7*), then put the mouth in the center of the circle (*8*) and then placed it correctly (*9*). She made horizontal lines "to judge distances." Date: Jan. 11, 1943.

(*B*) Notable improvement five months later (June 18, 1943). The patient again made lines across the circle, as in *A*, but in doing so she seldom touched the paper.

17. Engerth, G.: Zeichenstörungen bei Patienten mit Autotopagnosie, Ztschr. f. d. ges. Neurol. u. Psychiat. **143**:381-403, 1933.

18. Kleist, K.: Gehirn-Pathologie, vornehmlich auf Grund der Kriegserfahrungen, Leipzig, Johann Ambrosius Barth, 1934.

19. Poppelreuter, W.: Zur Psychologie und Pathologie der optischen Wahrnehmung, Ztschr. f. d. ges. Neurol. u. Psychiat. **83**:26-152, 1923.

OBJECT AGNOSIA

Inanimate Objects.—During the first two weeks the patient did not recognize any objects. For instance, she called a comb "a fountain pen," scissors "a hair pin" and a little toy elephant "a pencil." After color recognition had returned, she guessed the identity of an object by its color. For example, at the end of the second week she called a dish of vanilla ice cream "scrambled eggs." She always tried to grasp the object, and she was usually able to identify it by touch. From the third week on she frequently traced around the object with her right index finger, a method similar to that used when she tried to read. At first she perceived the contours only. For example, during the second week she called a nickel and a round, silver compact each "a key ring." Identical responses of agnostic patients are reported all through the literature. For instance, Lissauer's [20] patient called a straw hat "a ring." After three weeks she began to fill in the contours, but she did not perceive the third dimension. So she called a square, white box "a piece of paper." During the second month she gradually became able to register the third dimension. This process of adding up visual impressions has, up to now, remained her way of recognizing objects by sight. At the time of the report, no deviation from the norm in the patient's way of recognizing objects would be noticed by the untrained observer, since her ability to guess and to add has improved notably. Her handicap, however, can still be brought out by tachistoscopic examination. Thus, during the fourth month, a green toy battleship, 4 inches (10 cm.) long, was shown to her at a gradually increased time of exposure. She gave the following responses:

1 sec. ..... "A fountain pen."
2 sec. ..... "A knife, green."
3 sec. ..... "A boat."

She commented: "At first I saw the front part. It looked like a fountain pen because it was shaped like a fountain pen. Then it looked like a knife because it was so sharp, but I thought it could not be a knife because it was green. Then I saw the spokes and that it was shaped like a boat, like in a movie where I had seen boats. It had too many spokes to be a knife or a fountain pen." She also called a piece of white soap "a piece of paper" after looking at it for one second, but she identified it correctly after two seconds. Consequently, the time which she requires adds up to such an extent that her relatives think she has become "very slow."

20. Lissauer, H.: Ein Fall von Seelenblindheit nebst einem Beitrag zur Theorie derselben, Arch. f. Psychiat. **21**:222-270, 1890.

Since this condition has not improved within the last few months, one may anticipate that the patient will continue to recognize by adding up parts instead of by simultaneous perception of all the parts for some time to come, if not permanently.

Animate Objects.—During the first weeks following injury the patient was unable to recognize people by sight. She did not even recognize her husband when he visited her for the first time, one week after her admission, but she identified him when he took her hand in his characteristic way. She was also keen in recognizing voices and footsteps. However, up to the present she has not been able to recognize people when she sees them for the first time after her injury, even though she had known them well. Only after they have made themselves known to her does she recognize them, and she then is able to recognize them at later meetings. This shows that the patient must form new visual images and evidently has learned roundabout ways of recognition. This she does whenever she has considerable interest in a person. She does not recognize people whose conversation and personality are unessential to her, even if she has met them several times. On the other hand, she recognized a physician who had impressed her by a careful examination when she saw him for the second time in an elevator, although he did not recognize her. The patient trains herself to remember eyes, profiles, height and hair of different people. She is greatly helped by remembering voices and by anticipating whom she may meet. That the localization of the lesion within the occipital lobes may be correlated with a difference in impairment in recognition of animate and inanimate objects has been discussed by Nielsen and Sanborn [21] and by Olsen.[22] In this patient the disturbance in recognition of animate objects paralleled that of inanimate objects.

PICTURE AGNOSIA

The patient has more difficulty with the recognition of pictures than of objects. Colored pictures are recognized more easily than uncolored ones because in the former the details are impressed by the difference in color. Up to the present she has described pictures as children do, by enumerating details, one after the other. During the first two months she recognized only a few items out of the whole picture. Thus, her reaction to two colored pictures,[11] presented to her one month after injury, the first picture consisting of a boy admiring a sailboat in a toy shop, the second showing the same boy bent down over the sailboat, playing with it in a pool, was as follows: The patient pointed to the boy in each picture and said, "A boy." When asked whether it was the same boy, she answered in the negative. The different posture of the boy changed the visual impression made on the patient. She then pointed to the boat in each picture and identified it as such, but she did not recognize it as the same boat and said, "It has a different color," pointing to the waves and ripples at the left of the sail boat, which impressed her as a part of the boat. This could be interpreted as a "disturbance of figure-ground relationship." However, the analysis of previous errors has shown that such a disturbance was simulated by the patient's adherence to earlier optic impressions. She still misinterprets black and white drawings to a considerable extent but she recognizes most of the details in colored pictures and adds them up. Her difficulty is greatest if recognition of a plurality of details is necessary for the understanding of the picture because, when faced with many items, she always overlooks some. The name "simultanagnosia" has been given by Wolpert [23] to the disturbance in patients who perceive only parts of the whole picture. However, the symptoms in his, and in similar, cases, as well as in this case, indicate that such a disturbance is never confined to the recognition of pictures but that it is present in all optic recognition. The term "simultanagnosia" would be appropriate for this patient's condition except that this term is restricted by definition to the agnosia of pictures.

This disturbance also prevents the patient from enjoying a moving picture. Whenever the picture shows crowds, as in a battle or during a dance scene, the patient cannot understand what is going on. She enjoys, however, scenes which are carried by one or two actors only. The accompanying voices and her observation of movements contribute to her understanding.

A striking observation, which has been reported in simliar cases (Lissauer,[20] von Stauffenberg,[6] Heidenhain [7]), was made when objects or pictures which the patient had not been able to recognize were shown to her again later. In several instances she quickly stated that they had already been shown to her. This proves that the patient formed and stored visual images out of incomplete or erroneous visual impressions.

21. Nielsen, J. M., and Sanborn, A. L.: Agnosia for Animate Objects, Bull. Los Angeles Neurol. Soc. **7**: 102-104, 1942.

22. Olsen, C. W.: Mind-Blindness: Clinical and Pneumencephalographic Study of a Case of Infarction of the Brain, Bull. Los Angeles Neurol. Soc. **7**:43-47, 1942.

23. Wolpert, I.: Die Simultanagnosie-Störung der Gesamtauffassung, Ztschr. f. d. ges. Neurol. u. Psychiat. **93**:397-415, 1924.

ACALCULIA

In the beginning the patient was unable to calculate. She could count forward, but she made mistakes when counting backward. After two months she was able to count backward without mistake and to add and substract orally, but she could multiply only when the result was below 20. During the first four months she confused multiplication, substraction and addition, as well as the corresponding symbols. For instance, four months after injury, when asked how much was 9 times 7, she said, "Nine and 9 is 18 . . . and 7 . . . that would be 16." When it was repeated that she should multiply, not add, she succeeded in giving the right answer by reciting the multiplication table for 7 up to 63. At present, she is able to multiply all the digits correctly, but it is still almost impossible for her to do any dividing. Other methods of calculation are derived from adding, which was the patient's best ability. For dividing, however, one needs visualization of the whole that is to be divided. This causes unsurmountable difficulties for this patient, as well as for patients with a similar disturbance (see patient of Goldstein and Gelb [4]). The following responses were given during the fourth month of her illness:

63 divided by 9?	"That is taking away, isn't it?" When it was repeated that she should divide, she said, "I forgot how you divide."
10 divided by 5?	"That would be 50 . . . 5 . . . I mix it up with multiplication. Four 5's are 20. Wouldn't that make 5?"
6 divided by 3?	"Dividing or taking away? Is it 9? 3?"
4 divided by 2?	"That's 2. Two plus 2 is 4. You just take 2 away."

From now on the patient was instructed to practice dividing daily. The result was that she was able to remember some simple divisions for a while. But when practice was stopped, she forgot after a few days what she had remembered mechanically.

After she was able to recognize numbers by sight, she could read up to four digits correctly. But here, too, she does not perceive the number simultaneously but starts counting from the right to the left to find out its denomination. Anything beyond four digits causes unsurmountable difficulties. In the following sample is the patient's response six months after admission, when she was asked to read numbers:

4376	"1, 2, 3, 4." (The patient counted out the numbers 6, 7, 3, 4, according to their denomination.) When arrived at the 4, she said, "Four, that's thousand. Therefore, four thousand three hundred and seventy-six."
42179	"Four hundred and twenty-one thousand seventy-nine."

Thus, the patient just read one digit after the other without being able to make a proper division of the whole number.

After having been at first totally unable to tell the time, the patient worked out a system which is analogous to that reported for other patients with visual agnosia. Three months after injury, she reported: "I practice telling time. The 6 is below the 12 and the 9 across from the 3 on the watch. First I look for the hands to find which is the hour hand and which is the minute hand. Then I look for the numbers. I memorize that 1 means 5 minutes; 2, 10 minutes; 3, 15 minutes, and so on." Up to now, however, the patient confuses hour and minute hands and therefore makes mistakes. This difficulty is typical not only of agnostic but of aphasic patients (Head [5]). Normally, telling the time is done through simultaneous perception of the familiar sight of the watch, without the need of additional calculation.

The patient is able to say without hesitation which one of two numbers is greater, but she is unable to explain the difference in an abstract, mathematical way. For example, when asked why 72 was more than 45, she said, "Because you can buy more for 72 cents than for 45 cents." Seemingly unessential variations of such a question confuse her. For instance, during the fourth month, she handled a problem as follows:

Which is more, four times 3 or six times 2?	"Four times 3. Six times 2 is 18 . . . No, four times 3 is 18, Six times 2 is 12, so four times 3 would be more . . . No, 6 2's are 18 . . . No, 3 is more than 2. Therefore, four times 3 would be more than six times 2."

Thus, the two problems impose themselves on each other, and a separation of the whole problem into its proper parts proves to be impossible.

During the first month she was unable to indicate the number of days in a year or in a week. Ever since she has practiced this. But although she has improved, she is still not able to get it straight. Her estimation of time, for example, how many minutes had passed after she entered a room, does not seem to be impaired. Neither is her sense of rhythm, and she is good at imitating any rhythm that is tapped out.

Acalculia is present in all cases of pronounced optic-agnostic disturbance, in particular those with severe geometric-agnostic symptoms. It is also present, however, in cases of aphasia and apraxia. Consequently, the localization of lesions causing acalculia varies with different patients.

FINGER AGNOSIA

The patient is able to show, on request, any of her fingers. She does this by counting them

until she arrives at the one she is to show. If she is asked to name a finger on another person's hand or to show the same finger as that shown to her by another person, she first has to identify the thumb. If it is hidden, she is unable to recognize any finger. Patients with finger agnosia are usually able to recognize the first and the fifth finger. Since the contours of the first and the fifth finger are a continuation of those of the hand, the patient identifies them comparatively easily. Recognition of the second, third and fourth fingers by sight is difficult, since the patient cannot register their minute differences.

The finger agnosia of this patient is the same now as it was during the first weeks. She said herself: "If you show me all the fingers of your hand together and point to one, I can tell you which one it is because I can count. But if you show me only one and hide the others, I cannot make out which finger it is."

Such disturbances of awareness of bodily relations are usually accompanied by impairment in left-right orientation. This patient was unable to indicate left and right during the first two weeks. By the end of the third week, when asked about it, she invariably made the movement of writing with her right hand and said, "I write with this hand; therefore, this is the right one." At present; she still identifies right and left by "thinking."

Since its first description by Gerstmann,[24] finger agnosia has been observed to be associated with various lesions of the left hemisphere. Lange [25] differentiated finger agnosia caused by aphasic disorders from that due to apractic and agnostic disturbances. In the present case finger agnosia is a part of the optic-agnostic syndrome. A parallel can be drawn between this patient's finger agnosia and her visual alexia inasmuch as the patient cannot recognize the fingers on another's hand (impairment in reading), is unable to find out which of her own fingers corresponds to the one shown to her (impairment in copying) but on command can show her own fingers correctly (preservation of writing).

SPECIAL TESTS

Electroencephalogram. — Electroencephalographic examinations,[26] done three weeks and four months after injury, revealed a "very low voltage record, no build-up with over ventilation, no slowing and no definite focus of abnormal activity. No marked difference was noted between the first and the second encephalogram."

Examination of Visual Acuity and of Visual Fields.—The disturbance of reading complicates the examination of visual acuity of optic-agnostic patients. The best method is to find the shortest distance necessary for the subject to count two or three dots, for instance, chalk dots on a blackboard, and to compare this distance with that required by an emmetropic person. When the patient was examined in this way, her visual acuity was normal. She was able to recognize letters of the smallest print when they were exposed close to her, a fact which also proves that her visual acuity is normal. However, when her vision was examined with the Snellen tables at a distance of 20 feet (6 meters), it was easier for her to recognize large letters than small ones. By this method of examination visual acuity is not much above 20/70 for either eye. This apparent discrepancy, which has also been reported for other optic-agnostic patients (Goldstein and Gelb [4]), might be explained by the fact that the patient reads by tracing the contour of a letter. Such a procedure is more difficult if performed over long distances than at close range.

On examination of her visual fields the patient has difficulty in fixing one point and at the same time in watching for the approaching target. But she can accomplish the task if she is told from what direction she is to anticipate the target. The visual fields are then normal (fig. 11). There is perhaps a slight constriction of the right lower visual field for color, particularly in the right eye. If present, it is too small a variation to produce any recognizable, additional symptoms. Examination for perimacular amblyopia or scotomas gave negative results.

Wide Range Vocabulary Test.—Since the usual, widely used intelligence tests require intact visual perception, a routine evaluation would be misleading in the case of this patient. Therefore, only the wide range vocabulary test of C. R. Atwell and F. F. Wells, form B, was used. The patient's intelligence, in terms of this test, was at a 16 year level, which corresponds to high school performance. By the same test, the average adult score is 50, which means 50 correct answers to 100 questions. The patient's score was 65, and therefore somewhat above average.

ADAPTATION TO ORDINARY LIFE

After the initial confusion had passed, the patient gave to the inexperienced observer the

24. Gerstmann, J.: Syndrome of Finger Agnosia, Disorientation for Right and Left, Agraphia and Acalculia: Local Diagnostic Value, Arch. Neurol. & Psychiat. **44**:398-408 (Aug.) 1940.

25. Lange, J.: Agnosien und Apraxien, in Bumke, O., and Foerster, O.: Handbuch der Neurologie, Berlin, Julius Springer, 1936, vol. 6, pp. 807-960.

26. Interpretation was made by Mrs. Erna L. and Dr. Frederic A. Gibbs.

impression of a normal person. However, her family is aware of several rather obvious disabilities. At home, four weeks after her admission, she confused the silver on the table. When getting dressed she had difficulties, confusing her underwear with her blouse and not getting her arms into the right sleeves. After the first three months these errors did not recur. Twice she fell down steps when descending, and she comments that she is likely to overlook steps. She has no difficulty in walking up. The same disturbance was reported by Wilbrand's agnostic patient.[15] The patient's reading difficulties prevent her from cooking, since she confuses the different ingredients marked by labels. When sewing, she misplaces the stitches and therefore has given it up after several attempts. She takes care of her laundry, but the result is poor because she misses soiled parts. She is able to iron material of simple geometric forms, such as handkerchiefs and towels, but with more complicated patterns she omits parts. For instance, recently she did not iron the collar on her blouse. When using the vacuum cleaner she omits sections of the rug. When crossing busy street intersections she frequently overlooks approaching cars because she perceives only parts of the whole situation. Consequently, she avoids such places, unless they are protected by traffic lights.

Several times a day she asks what time and what day it is. Her family is worried because she has lost the ability to attend to her financial affairs. She spends the money allotted to her on incidentals, instead of budgeting. This is in keeping with her impairment in calculation.

Apart from these obvious difficulties and her slowness, which is caused by her way of visual recognition, neither her family nor her friends notice any change in the patient's personality. She shows adequate affect and interest, and it is possible to conduct any ordinary conversation with her. She is reasonably concerned about her husband, who joined the Army in March 1943. Her logic is undisturbed, and she immediately notices absurdities which are purposely inserted into a conversation.

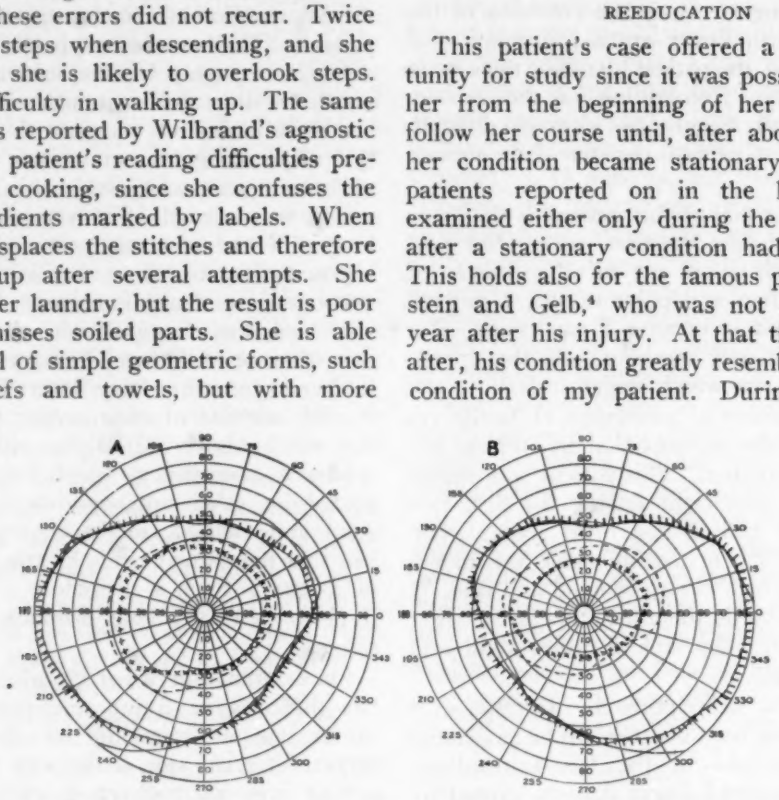


Fig. 11.—Visual fields for (*A*) the left eye and (*B*) the right eye. The fields for white are indicated by a line with hatching; the fields for blue, by a broken line, and the fields for red, by a line of crosses. Date, June 19, 1943; target, 1 degree.

REEDUCATION

This patient's case offered a unique opportunity for study since it was possible to observe her from the beginning of her illness and to follow her course until, after about six months, her condition became stationary. Most of the patients reported on in the literature were examined either only during the initial stage or after a stationary condition had been reached. This holds also for the famous patient of Goldstein and Gelb,[4] who was not studied until a year after his injury. At that time, and thereafter, his condition greatly resembled the present condition of my patient. During the patient's period of rehabilitation she developed methods to compensate for her impairment of visual perception. She traces the contours of letters with her index finger in order to enforce visual perception and to replace recognition of the whole, which is denied her, by a substitute method of recognition, namely, that of adding up parts. She has trained herself to recognize letters by their outstanding characteristics, and she is still perfecting this. She uses "thinking," which consists of combining, anticipating and guessing, in order to make up for her disability, and she is keen in the use of touch, hearing, smell and taste during the process of recognition. She has formed new visual images which enable her to recognize people by a few outstanding characteristics. All these roundabout ways she found by herself in her struggle for readjustment. The question arises as to what can be done by others to help such patients. The course of recovery

of this patient indicates that the most important principle is not to interfere with improvisations, but to encourage them. There are limits to what can be overcome. For example, although the patient has learned to recognize simple patterns, she has made no progress in recognizing complicated ones. For a while efforts were made to improve her copying of complicated figures, with no success at all. In order that she hold what she has regained, continued practice is necessary. This can be seen from the fact that she began to confuse seldom used letters, such as *q* and *z*, after her condition had become stationary. Calculation, especially, has to be practiced since much of it becomes a matter of remembering mechanically if visualization is impaired. Continued supervision is advisable. Similar opinions have been expressed by Goldstein [27] and by Weisenburg and McBride.[28]

COMMENT

In all probability, the lesions in the brain in this case were the result of exposure to carbon monoxide fumes. Carbon monoxide was found in the blood of many victims of the Cocoanut Grove fire in amounts sufficient to kill. Although the Babinski reflex could be elicited initially in several patients, none of the other 131 patients who were admitted to the Boston City Hospital during the night of the disaster gave evidence of a permanent cerebral lesion. Only 1 other patient has sustained permanent neurologic damage. In this patient, 1 of the 39 admitted to the Massachusetts General Hospital (Cobb and Lindemann [29]), widespread damage both to the basal ganglia and to the white matter is assumed, which resulted in psychomotor, intellectual and aphasic disturbance.

Impairment of higher cortical function in survivors of carbon monoxide poisoning has been noted frequently. Visual agnosia in particular has been described in such patients by Schilder and Isakower,[30] Solomon [31] and Von Hagen.[32]

Lesions of the occipital lobe were stated to be present in all cases of visual agnosia in about 50 autopsy reports in the literature. Nielsen [33] and others pointed out that the lesion in the occipital lobe may be unilateral. In this case the lesion is probably bilateral, since lesions in the brain caused by carbon monoxide poisoning are usually symmetric and so little compensatory improvement occurred.

Different investigators (Henschen,[12] Kleist,[18] Nielsen and FitzGibbon,[1] Poetzl [2]) have attributed separate localizing significance to object agnosia, picture agnosia, geometric agnosia, acalculia, visual alexia and related symptoms. In view of the identity of mechanism exhibited by this patient for each of these disorders, the question may be raised whether the various symptoms may not be caused by the same lesion of the occipital or the occipitoparietal lobe, as proposed by Goldstein and Gelb.[4] On the other hand, no two patients with visual agnosia represent an identical picture. The intensity of the different symptoms varies, as does their accentuation. Difference in psychologic development of higher cortical function may account for this.

The present case offers the following advantages for study: The patient has sufficient, even somewhat above average, intelligence and considerable insight, so that she is able to furnish a great deal of information about the motives underlying her methods. She is only 22 years old, whereas most patients with similar disturbances were nearer 60. Brain [16] has given the only description of visual agnosia in a child. There is no accompanying aphasia or apraxia, which in the majority of cases confuses the picture. Though her initial confusion suggests the presence of multiple cerebral lesions at that time, the symptoms during the later stages conform to the syndrome of visual agnosia caused by occipitoparietal damage. Even during the first week of her illness the agnosia was limited to vision, whereas identification through other senses was intact. There is no impairment of visual acuity and no accompanying hemianopsia. Some authors (Brain,[16] Nissl von Mayendorf,[34] Poppelreuter [19]) have suggested that a patient's inability to perceive the whole might be caused by a defect in the visual fields and that this was the case in Goldstein and Gelb's [4] agnostic

27. Goldstein, K.: After Effects of Brain Injuries in War: Their Evaluation and Treatment, New York, Grune & Stratton, Inc., 1942.

28. Weisenburg, T., and McBride, K. E.: Aphasia, New York, Commonwealth Fund, 1935.

29. Cobb, S., and Lindemann, E.: Neuropsychiatric Observations, Ann. Surg. **117**:814-824, 1943.

30. Schilder, P., and Isakower, O.: Optisch-räumliche Agnosie und Agraphie, Ztschr. f. d. ges. Neurol. u. Psychiat. **11**:102-142, 1928.

31. Solomon, A. P.: Acalculia, Other Agnosias and Multiple Neuritis Following Carbon Monoxide Poisoning, M. Clin. North America **16**:531-538, 1932.

32. Von Hagen, K. O.: Two Clinical Cases of Mind Blindness (Visual Agnosia), One Due to Carbon Monoxide Intoxication, One Due to Diffuse Degenerative Process, Bull. Los Angeles Neurol. Soc. **6**:191-194, 1941.

33. Nielsen, J. M.: Unilateral Cerebral Dominance as Related to Mind Blindness: Minimal Lesion Capable of Causing Visual Agnosia for Objects, Arch. Neurol. & Psychiat. **38**:108-135 (July) 1936.

34. Nissl von Mayendorf: Beiträge zur Lehre von der Seelenblindheit, Ztschr. f. d. ges. Neurol. u. Psychiat. **159**:226-250, 1937.

patient. Goldstein [35] has presented evidence to disprove the validity of this opinion. That this is not necessarily so is also proved by the observations on this patient, as well as by those on other patients who had no defect in the visual field (Jossmann,[36] Wilbrand and Sänger,[37] Wolpert [23]). In addition, it has commonly been observed that a bilateral hemianopsic defect, sometimes with sparing only of macular vision, was not accompanied by any agnostic disturbance. Several such patients had learned to shift their maculas, and they traced the contours of the object with their heads. It may be that the constriction of the visual fields in the patient of Goldstein and Gelb [4] caused the peculiar tracing movements of his head, particularly since this symptom has not been observed in other agnostic patients with intact visual fields.

This patient's agnosia belongs to the "apperceptive" (which is the same as perceptive) type. Lissauer [20] described this disturbance as one resembling "the condition of a person whose optic impressions are limited to light and difference of colors but who no longer has any concept ot forms and objects. . . . The recognition of the outer world is made impossible primarily because of insufficient perception." This type of agnosia can be separated from that of "associative" visual agnosia, which was also described by Lissauer.[20] Patients with the latter type of agnosia perceive forms correctly, or approximately correctly, but their perception has no meaning for them. A survey of the literature reveals that the majority of patients have a mixed type, presenting both apperceptive and associative disturbances. Conditions such as that of my patient, whose symptoms are predominantly caused by a disturbance of perception, are rare. The type of agnosia a patient presents is best indicated by whether he is or is not able to copy. If, like this patient, he cannot copy, he has a disturbance of perception. If he can copy, but cannot identify what he has copied, his disturbance is on a higher level and represents an impairment in association of visual perception with the optic image in the cortex.

In this patient recognition through simultaneous perception of all the parts has deteriorated into perception of parts. To achieve some recognition of the whole, she has to add up details, thus requiring more time for recognition than is normal. In an attempt to shorten this procedure the patient resorts to guessing. Consequently, she frequently errs, if it is not possible to identify the whole from the parts she has perceived. The name "simultanagnosia" would be a good characterization of this disturbance, except that Wolpert [23] has reserved this term for inability to perceive the whole of a picture only.

Liepmann [38] compared the confusion experienced by agnostic patients with that of a normal person when he looks at concealed object pictures which to him give the impression of meaningless lines. Anticipation of what one may find helps to unravel the lines. In such pictures the "figure-ground relationship" has been artificially confused. Goldstein and Gelb [4] have suggested that a disturbance of this relationship is of fundamental importance in patients with lesions of the brain. Such a disturbance is also suggested by this patient's errors: She builds the white background into the block design when she is trying to copy a pattern, and she misinterprets pictures by confusing the background with the important figure. Especially when she is reading, previously seen words impose themselves on subsequent ones and interfere, regardless of whether these words have been recognized or not. All this shows that the patient is caught by previous optic impressions, which superimpose themselves on subsequent ones, with resulting misinterpretations. When adding up subsequent visual perceptions, the patient habitually proceeds from the left or above to the right or below, which is the direction of writing. Therefore, the visual impressions to which she adheres are mainly to the left and above. This perseveration of optic impressions and subsequent interference with visual performance is not a "disturbance of figure-ground relationship," although the patient's errors may suggest such an interpretation.

Visual agnosia is occasionally misinterpreted as "hysteria" by persons with no experience in this field. Like many organic diseases, visual agnosia, too, can be imitated by a functional disorder (Teitelbaum,[39] van Vleuten [40]). If repeated examinations can be made, it is not difficult to differentiate the organic from the functional condition, since all the errors associated with visual agnosia follow the same pattern. A clear indication that the disease is caused by

35. Goldstein, K.: Some Remarks on Russel Brain's Article Concerning Visual Object Agnosia, J. Nerv. & Ment. Dis. **98**:148-153, 1943.

36. Jossmann, P.: Zur Psychopathologie der optisch-agnostischen Störungen, Monatschr. f. Psychiat u. Neurol. **72**:81-149, 1929.

37. Wilbrand, H., and Sänger, A.: Die Neurologie des Auges, Wiesbaden, J. F. Bergmann, 1917, vol. 7, pp. 393-446.

38. Liepmann, H.: Ueber die agnostischen Störungen, Neurol. Centralbl. **27**:609-617, 1908.

39. Teitelbaum, H. A.: Psychogenic Body Image Disturbances Associated with Psychogenic Aphasia and Agnosia, J. Nerv. & Ment. Dis. **93**:581-612, 1941.

40. van Vleuten, C. F.: Funktionelle Seelenblindheit, Centralbl. f. Nervenh. u. Psychiat. **28**:49-64, 1905.

a lesion of the brain is the presence of optic perseveration, which is hardly ever observed with hysteria. Misinterpretations and conclusions arrived at by guessing are also more apt to occur in visual agnosia, since hysterical patients rarely misinterpret, but usually bluntly comment that they do not recognize what is shown them.

SUMMARY

A case of visual agnosia in a woman aged 22 has been described, the course of the illness having been followed from the first day until the condition became stationary. The patient is 1 of the 2 persons in whom permanent lesions of the brain were produced, probably by carbon monoxide fumes, in a fire disaster at a night club on Nov. 28, 1942.

The fundamental disturbance consists of the patient's inability to perceive the whole, the *Gestalt,* visually. Only parts of the whole are perceived, and their correct relation is not recognized. This results in an inability to read, to copy letters and geometric figures and to recognize pictures or objects on short exposure. Writing is unimpaired.

Owing to the patient's intelligence and insight into her disability, it was possible to identify an additional disturbance in the nature of a perseveration of visual attention and optic impressions. Preceding optic impressions superimpose themselves on subsequent ones, so that proper perception and recognition are interfered with. This symptom is of the same category as psychomotor perseveration and perseveration of speech and writing.

According to Lissauer's first description, such a condition belongs to the "apperceptive" type of visual agnosia, since there is a primary disturbance of optic perception. In this patient the disturbance is clearcut to an unusual degree. The identity of the mechanism exhibited by this patient in each of the disorders of visual performance makes it unlikely that the various symptoms of optic agnosia have a separate localizing significance.

Compensatory efforts to build up new methods of visual recognition should be encouraged. Constant practice is necessary, since such a patient is likely to distort and to forget what he has learned.

Harvard Medical School.

PSYCHOPHARMACOLOGIC STUDY OF SCHIZOPHRENIA AND DEPRESSIONS

INTRAVENOUS ADMINISTRATION OF SODIUM AMYTAL AND AMPHETAMINE SULFATE SEPARATELY AND IN VARIOUS COMBINATIONS

JACQUES S. GOTTLIEB, M.D.
IOWA CITY
AND
CAPTAIN FRANK E. COBURN
MEDICAL CORPS, ROYAL CANADIAN ARMY

The intravenous administration of sodium amytal has been employed in the study of various psychoses since the introduction of the method by Blackwenn [1] in 1930. He used the drug to produce rest and sleep, and on the patient's recovery from the narcosis he noted brief lucid periods. Lindemann [2] then demonstrated that similar, and equally prolonged, remissions could be produced by intravenous administration of the drug in doses which were insufficient to cause sleep. Striking changes were frequently produced in resistive and mute schizophrenic patients. Their attitude changed from that of resistiveness, withdrawal and seclusiveness to one of friendliness and emotional warmth. There were willingness to discuss personal problems and a desire to retain the condition produced by the drug. The structure of the delusional and hallucinatory systems was not altered, however—in contrast to the improvement in contact with the environment, with respect both to communication and to warmth of emotion.

Since its introduction sodium amytal administered intravenously in subnarcotic doses has been employed extensively for various purposes. It is helpful as a diagnostic tool, permitting clarification of the mental content and the structure of the illness. It therefore has value in differential diagnosis.[3] The total reaction frequently leads to a revelation of hidden thoughts, which allows a search for and discussion of the patient's critical experiences and attitudes. It therefore is an aid in psychotherapy.[4] The type of response obtained in a schizophrenic patient is of assistance in evaluation of the prognosis. The more closely the patient's behavior approaches normal under the influence of the drug, the better the outlook.[5] Furthermore, it has value for investigative purposes, allowing psychometric and other studies of intellectual and emotional functions.[6]

Since the reaction of a psychotic patient to the intravenous injection of sodium amytal is of diagnostic, therapeutic, prognostic and investigative importance, attempts have been made to improve the response to this drug. Drowsiness and shortness of reaction frequently mask the desired effect. As a result, various stimulants of the central nervous system, such as caffeine and sodium benzoate,[7] metrazol [8] and amphet-

From the Iowa State Psychopathic Hospital, State University of Iowa College of Medicine.

Read at the Ninety-Ninth Annual Meeting of the American Psychiatric Association, Detroit, May 11, 1943.

Amphetamine sulfate prepared for intravenous administration was supplied by the Smith, Kline & French Laboratories, Philadelphia.

1. Blackwenn, W. J.: Narcosis as Therapy in Neuropsychiatric Conditions, J. A. M. A. **95**:1168 (Oct. 18) 1930.

2. Lindemann, E.: Psychological Changes in Normal and Abnormal Individuals Under the Influence of Sodium Amytal, Am. J. Psychiat. **88**:1083 (May) 1932.

3. Berrington, W. P.: Psycho-Pharmacologic Study of Schizophrenia, with Particular Reference to Mode of Action of Cardiazol, Sodium Amytal and Alcohol in Schizophrenic Stupor, J. Ment. Sc. **85**:406 (May) 1939. Sullivan, D. J.: Psychiatric Uses of Intravenous Sodium Amytal, Am. J. Psychiat. **99**:411 (Nov.) 1942.

4. Wagner, C. P.: Pharmacological Action of the Barbiturates: Their Use in Neuropsychiatric Conditions, J. A. M. A. **101**:1787 (Dec. 2) 1933. Longpre, F.: Sodium Amytal Combined with Psychotherapy in Non-Cooperative and Cataleptic Patients, Massachusetts Dept. Ment. Health, Symposium on Therapy, 1939, p. 5.

5. Gottlieb, J. S., and Hope, J. M.: Prognostic Value of Intravenous Administration of Sodium Amytal in Cases of Schizophrenia, Arch. Neurol. & Psychiat. **46**:86 (July) 1941.

6. Layman, J. W.: A Quantitative Study of Certain Changes in Schizophrenic Patients Under the Influence of Sodium Amytal, J. Gen. Psychol. **22**:67 (Jan.) 1940.

7. Broder, S. B.: Therapy in Catatonia: Effects of Combining Caffeine Sodium Benzoate with Sodium Amytal, Am. J. Psychiat. **93**:957 (Jan.) 1937.

8. Reitman, F.: Some Observations on Sodium Amytal Experiments: Preliminary Report, J. Ment. Sc. **87**:96 (Jan.) 1941.

amine sulfate,[9] have been employed in an attempt to improve the type of response, to decrease drowsiness and to prolong the reaction.

Our purpose in this study was to evaluate the psychologic effects of combined intravenous injections of sodium amytal and amphetamine sulfate in patients with schizophrenia or depressions. In preliminary studies on selected subjects, i. e., patients with schizophrenia who were mute, resistive and in poor contact with the environment and patients with depressions of various types, there were apparent improvement of response, diminution of drowsiness and prolongation of the desired effect. The fact, however, that amphetamine sulfate combined with sodium amytal seemed to improve the response in selected patients is not necessarily assurance that the same effect will be obtained in all patients with similar disturbances. A "good" response to the intravenous injection of sodium amytal, for instance, occurred in 15 of 100 schizophrenic patients tested, an incidence of only 15 per cent.[5] The present study, then, was designed to evaluate the psychologic responses produced by various combinations of these two drugs in typical patients with schizophrenia or depression. No effort was made to report the physiologic responses, as they were qualitatively consistent with those reported by Myerson and his associates.[10]

METHOD

Twenty consecutive patients[11] admitted to the hospital who were suitable for testing, 10 of whom had schizophrenia and the other 10 depressions, were subjected to the following routine procedure:

On five successive days the patient was given one of a series of intravenous injections of the drugs early in the morning, the type and duration of the response and the degree of narcosis being noted. The doses of the drugs were always the same: 250 mg. of sodium amytal and 10 mg. of amphetamine sulfate. In the first injection sodium amytal alone was given; in the second, amphetamine sulfate; in the third, sodium amytal followed immediately by amphetamine sulfate; in the fourth, amphetamine sulfate followed by sodium amytal, and in the fifth, a mixture of sodium amytal and amphetamine sulfate. This procedure was selected because we were interested in a comparison of the reactions of the patient rather than in obtaining the best responses possible by variations in the doses of the drugs. Except for the tolerance built up to the barbiturate, the preliminary studies indicated that the order in which the combined drugs were given was immaterial.

The reactions were evaluated as good, moderately good and poor. For the patient with schizophrenia, a good reaction was defined as one in which the affect was warm and appropriate to the thought content, the associations normal and the insight good so far as the patient recognized that he was ill. A moderately good reaction was defined as improvement in affect, associations and insight with persisting evidence of abnormalties. A poor reaction was defined as considerable defect in affect and thinking or as failure to respond.

For the patient with a depression a good reaction was defined as a shift of the affective state to or nearly to the normal level and, at the same time, disappearance of all evidence of retardation or agitation, whichever was present. A moderately good reaction was one in which there were definite improvement in the affective state and diminution of retardation or agitation but abnormalities were still evident. A poor reaction was characterized by no significant change in any of the symptoms or by complete failure to respond.

RESULTS

In table 1 are presented the duration and type of response elicited by the various combinations of the two drugs in the 10 depressed patients. The duration of the response was determined to the nearest half-hour. The reactions to the initial injection of sodium amytal were good in 3 patients, moderately good in 4 patients and poor in 3 patients. The average duration of the response was two and four-tenths hours. The intravenous injection of 10 mg. of aphetamine sulfate produced mildly increased tension, tearfulness and agitation in 3 patients and no response in 7 patients. When injection of sodium amytal was followed immediately by injection of amphetamine sulfate, 1 patient had a good reaction and 9 patients moderately good reactions. The average duration of the response was five and eight-tenths hours. When amphetamine sulfate was followed by sodium amytal, 1 patient had a good reaction, 6 moderately good reactions and 3 poor reactions. The average duration of the response was three and twenty-five–hundredths hours. When sodium amytal and amphetamine sulfate were injected together, 1 patient had a good response, 6 moderately good responses and 3 poor responses. The average duration of the response was five and six-tenths hours.

In summary, the psychologic characteristics of the reactions were not significantly changed for the group of depressed patients by the addition of amphetamine sulfate to the sodium amytal, but the duration of the response was increased. The narcotic effects were somewhat less prominent. From this table it appears that the longest reactions were obtained when the two drugs were given in mixture or the sodium amytal was given

9. Myerson, A.: The Reciprocal Pharmacological Effects of Amphetamine (Benzedrine) Sulfate and the Barbiturates, New England J. Med. **221**:561 (Oct. 12) 1939.

10. Myerson, A.; Roman, J.; Rinkel, M., and Lesses, M. F.: The Effect of Amphetamine (Benzedrine) Sulfate and Paradrine Hydrobromide on Sodium Amytal Narcosis, New England J. Med. **221**:1015 (Dec. 28) 1939.

11. Schizophrenic patients who showed no response to sodium amytal were omitted from this study, for obvious reasons. One patient with a depression was omitted from the study because of an atypical response.

first. There were of course exceptions to the general rule, as evidenced in case 6, in which the initial reaction to sodium amytal alone was as long as any of the subsequent reactions.

average duration of the response was three and nine-tenths hours. To amphetamine sulfate given alone there were failure of response in 6 patients and slight changes, characterized by increased

TABLE 1.—*Responses of Patients with Depressions to Sodium Amytal and Amphetamine Sulfate Alone and in Combinations*

Case No.	Diagnosis *	Sodium Amytal, 250 Mg.		Amphetamine Sulfate, 10 Mg.		Sodium Amytal Followed by Amphetamine Sulfate		Amphetamine Sulfate Followed by Sodium Amytal		Sodium Amytal and Amphetamine Sulfate Together	
		Response	Duration, Hr.	Response	Duration, Hr.	Response	Duration, Hr.	Response	Duration, Hr.	Response	Duration, Hr.
1	M. D. D.	Good	1½	Tense; tearful; agitated	4	Moderately good (drowsy)	5	Moderately good (drowsy)	2½	Poor (drowsy)	5½
2	M. D. M.	Good (drowsy)	4	None	0	Moderately good (drowsy)	6½	Moderately good (drowsy)	6	Poor	5
3	M. D. P.	Good	6½	None	0	Good	9½	Good	5½	Good (sleepy)	12
4	I. M.	Poor (drowsy)	½	Slightly restless	½	Moderately good	7½	Poor	0	Moderately good	10½
5	M. D. D.	Moderately good (sleepy)	½	None	0	Moderately good	2½	Moderately good (drowsy)	2½	Moderately good	1½
6	M. D. D.	Moderately good	2½	Tearful; agitated	1½	Moderately good (drowsy)	½	Moderately good	2½	Moderately good	1½
7	M. D. D.	Poor (sleepy)	½	None	0	Moderately good (sleepy)	12	Moderately good (sleepy)	6	Moderately good (sleepy)	6
8	I. M.	Moderately good (sleepy)	1	None	0	Moderately good	1½	Poor	2	Moderately good	2
9	I. M.	Poor (sleepy)	1½	None	0	Moderately good	9	Poor (sleepy)	2	Poor (sleepy)	4
10	M. D. D.	Moderately good	5½	None	0	Moderately good	4	Moderately good	3½	Moderately good	8
Average			2.4				5.8		3.25		5.6

* M. D. D. indicates manic-depressive psychosis, depressive type; M. D. M., manic-depressive psychosis, mixed type; M. D. P., manic-depressive psychosis, perplexed type, and I. M., involutional melancholia.

TABLE 2.—*Responses of Patients with Schizophrenia to Sodium Amytal and Amphetamine Sulfate Alone and in Combinations*

Case No.	Type of Schizophrenia	Sodium Amytal, 250 Mg.		Amphetamine Sulfate, 10 Mg.		Sodium Amytal Followed by Amphetamine Sulfate		Amphetamine Sulfate Followed by Sodium Amytal		Sodium Amytal and Amphetamine Sulfate Together	
		Response	Duration, Hr.	Response	Duration, Hr.	Response	Duration, Hr.	Response	Duration, Hr.	Response	Duration, Hr.
1	Paranoid	Good (sleepy)	3½	None	0	Moderately good	2½	Poor (drowsy)	6½	Moderately good (drowsy)	4
2	Paranoid	Moderately good (drowsy)	4	None	0	Moderately good	2	Poor	1½	Moderately good	3
3	Hebephrenia	Good (drowsy)	½	None	0	Good	4	Poor	3	Moderately good	5
4	Undifferentiated	Good	1	None	0	Good	6	Good	2	Good	3½
5	Hebephrenia	Good	7½	Tense; restless	½	Moderately good	1½	Moderately good	1½	Moderately good	1½
6	Undifferentiated	Moderately good	5½	None	0	Moderately good (drowsy)	2	Moderately good	3	Moderately good (sleepy)	5½
7	Hebephrenia	Good (sleepy)	5½	Tense; tearful	½	Moderately good	7	Moderately good	10	Good	7
8	Hebephrenia	Poor (sleepy)	4½	None	0	Moderately good	2	Poor (drowsy)	9	Moderately good (drowsy)	3
9	Undifferentiated	Moderately good (sleepy)	5	Tense; restless	1	Moderately good	2	Moderately good	8½	Moderately good (drowsy)	5
10	Paranoid	Poor (drowsy)	2	Agitated; depressed	2	Poor	2	Poor	½	Poor	1½
Average			3.9				3.1		4.55		3.9

In table 2 are presented the psychologic effects in 10 schizophrenic patients of sodium amytal and amphetamine sulfate, given separately and in various combinations. To sodium amytal alone 5 patients gave a good reaction, 3 moderately good reactions and 2 poor reactions. The

talkativeness, restlessness and tension, in 4 others. When sodium amytal was followed by amphetamine sulfate, 2 patients gave good reactions, 7 moderately good responses and 1 a poor response. The average duration was three and one-tenth hours. When amphetamine sulfate was

followed by sodium amytal, 1 patient gave a good reaction, 4 moderately good reactions and 5 poor reactions. The average duration was four and five-tenths hours. When the two drugs were given together, 2 patients gave good responses, 7 moderately good responses and 1 a poor response. The average duration was three and nine-tenths hours.

In summary, then, of the psychologic responses of the schizophrenic patients, the initial injection of sodium amytal alone produced the best, while injection of amphetamine sulfate followed by that of sodium amytal gave the poorest. The duration of the response when amphetamine was added to the amytal was increased for 4 of the 10 patients, was not significantly changed for 2 patients and was shorter for 4 patients. In most instances, however, the addition of amphetamine sulfate removed in part the narcotic effects of the sodium amytal. The average duration of the responses with the various combinations of the two drugs was approximately the same as that for the sodium amytal alone.

COMMENT

The data indicate that the addition of amphetamine sulfate to sodium amytal injected intravenously in patients with depressions does not change significantly the psychologic response to the drug except for dissipation of drowsiness to some degree and increase in duration of the effect. Furthermore, the best responses were obtained when the two drugs were given as a mixture or the amytal was injected first. In contrast, the schizophrenic patients showed on the average the same length of response, a slightly poorer psychologic reaction and a lessening of drowsiness. For individual patients the duration of the responses was increased. Other patients gave responses which were shorter. This may have been due to the observed phenomenon that subsequent responses to sodium amytal in schizophrenic patients often become poorer—indeed, sometimes they may fail to appear at all.[12] This is consistent with the tolerance which is known to develop to drugs of the barbiturate group.[13] Such tolerance, however, was not observed in the patients with depressions.

SUMMARY

A study of the psychologic effects in 10 patients with schizophrenia and in 10 patients with depressions of intravenous administration of sodium amytal and amphetamine sulfate alone and in various combinations revealed that the addition of the amphetamine diminished the drowsiness of both groups of patients and lengthened the response of the depressed patients.

Iowa State Psychopathic Hospital.

12. Unpublished data.

13. Tatum, A. L.: The Pharmacology of Barbiturates, in Luck, J. M., and Hall, V. E.: Annual Review of Physiology, Stanford University, Calif., Annual Reviews, Inc., 1940, vol. 2.

SITE OF ORIGIN OF FASCICULATIONS IN VOLUNTARY MUSCLE

FRANCIS M. FORSTER, M.D., AND BERNARD J. ALPERS, M.D.
PHILADELPHIA

Involuntary contractions of groups of muscle fibers apparent through the intact skin, and known as fasciculations, have long been considered as evidence of disease of the anterior horn cells. This opinion has resulted from their appearance in cases of disease involving the anterior horn cells. The increase of fasciculations produced by prostigmine and some of the observations reported on the effect of nerve root and peripheral nerve block cast doubt on the central origin of these involuntary movements. These investigations were undertaken to determine the site of origin of fasciculations.

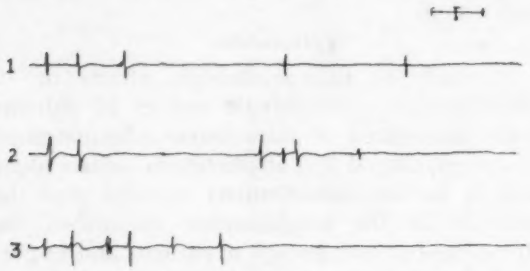


Fig. 1.—Sample tracings taken during a control period (*1*) and during periods of spinal anesthesia (*2*) and peripheral nerve block (*3*) demonstrate no significant change in the number of fasciculations. The horizontal marker indicates an interval of one second; the vertical marker, an amplification of 50 microvolts.

METHOD

Four patients were studied, 3 of whom had amyotrophic lateral sclerosis. The remaining patient had pronounced fasciculations, weakness and atrophy as residuals of acute infectious polyneuritis. Restless and poorly cooperative patients were not included in these studies, for by their automatic and voluntary movements the incidence of fasciculations would have been increased and inclusions of data for periods in which movement was not possible, such as those of nerve block and spinal anesthesia, would have resulted in a false and misleading reduction in the incidence of fasciculations. By the careful placing of extremities during the recording, postural movements were reduced to a minimum.

All records were taken by a three channel, condensor-coupled amplifier with an ink-writing oscillograph (Grass). The electrodes employed were coaxial needles, two small needles placed in the muscle 1 cm. apart and two solder disk electrodes similarly placed over the skin. All records were bipolar. Throughout a single experiment the electrodes were left in place. Prior to the administration of a drug or the carrying out of a procedure a control record of twenty to thirty minutes was obtained. The effect on the incidence of fasciculations was determined for the following agents: Prostigmine, acetylcholine and mecholyl, given intramuscularly; curare, administered intravenously; spinal anesthesia, and peripheral nerve block. The effects of the prostigmine and mecholyl were studied during spinal anesthesia, peripheral nerve block and curarization. The recorded frequencies of fasciculations throughout each of these experiments were charted for each patient.

From the Department of Neurology Jefferson Medical College of Philadelphia.

RESULTS

During spinal anesthesia the diphasic spikes associated with fasciculations were as prevalent as those appearing during the control period (figs. 1 and 3). Injection of procaine into the common peroneal nerve, resulting in paralysis, did not alter the frequency of fasciculations in the paralyzed muscles (figs. 1 and 4). The administration of prostigmine during spinal anesthesia (fig. 3) or peripheral nerve block (fig. 4) resulted in a notable increase in the number of fasciculations in the paralyzed muscles, comparable to the response to prostigmine without previous spinal anesthesia or nerve block.

Curarization resulted in the abolition of fasciculations (figs. 2 and 5). To obtain this result it was not necessary to carry curarization to the point of motor paralysis. Voluntary movement during partial curarization resulted in the usual burst of muscle spikes. These bursts were not followed by fasciculations, as was usually observed in control periods. The administration of prostigmine during curarization failed to induce fasciculations (fig. 5).

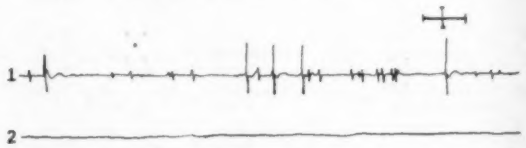


Fig. 2.—Sample tracings during a control period (*1*) and during a period of curarization (*2*) demonstrate the abolition of fasciculations by curarization. The values for time and amplification are the same as those indicated in figure 4.

Mecholyl in doses sufficient to produce systemic symptoms had no effect on the incidence of fasciculations during control states, spinal anesthesia, nerve block or curarization.

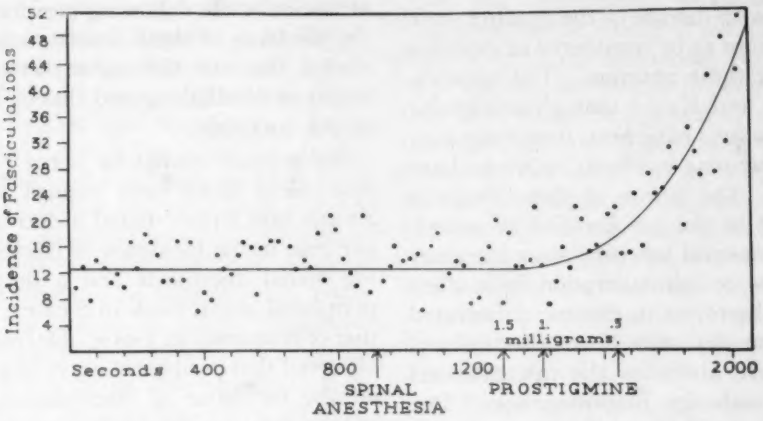


Fig. 3.—Chart showing the frequency of fasciculations during a control period and during spinal anesthesia. The incidence of fasciculations is plotted for consecutive twenty second intervals. The chart demonstrates no change in frequency of fasciculations during spinal anesthesia alone but a striking increase after administration of prostigmine during spinal anesthesia.

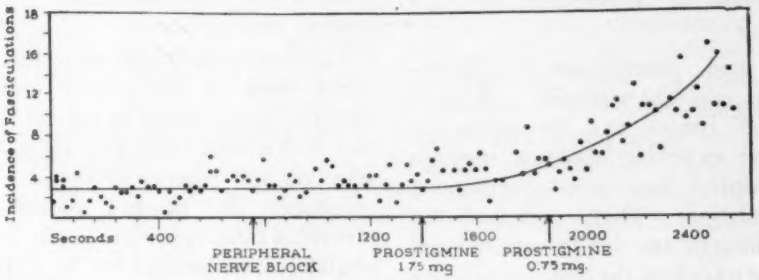


Fig. 4.—Chart showing the frequency of fasciculations during a control period and during peripheral nerve block (common peroneal nerve). The incidence of fasciculations recorded from the tibialis anticus muscle is plotted for twenty second intervals. The chart demonstrates no change in frequency of fasciculations during peripheral nerve block, but administration of prostigmine during such block resulted in a striking increase.

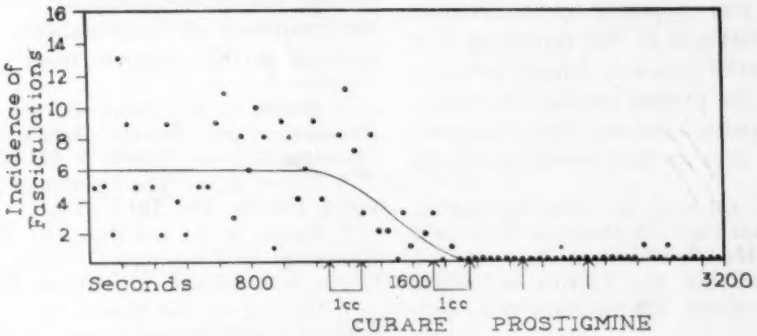


Fig. 5.—Chart showing the frequency of fasciculations during a control period and during curarization. The incidence of fasciculations was recorded at forty second intervals. The chart shows the abolition of fasciculations produced by curarization and the failure of prostigmine to induce their reappearance.

COMMENT

Since muscular fasciculations are most commonly observed with disease of the anterior horn cells, they have come to be considered as evidence of destruction of these neurons. The observations of Langley and Kato [1] that physostigmine produces fasciculations have been frequently confirmed, and prostigmine has been shown to have a similar effect. The action of these drugs is known to be due to the preservation of acetylcholine at the myoneural junction, since the characteristic response to administration fails when acetylcholine is absent, as in chronic denervated preparations. Langley and Kato also demonstrated that curare abolishes the fasciculations produced in animals by physostigmine. The effect of prostigmine and physostigmine on fasciculations was the first indication that fasciculations might arise wholly or in part at the myoneural junction. The only evidence of pathologic change at the myoneural junction in progressive muscular atrophy is the as yet unconfirmed observations of Pommé and Noël.[2] These authors described a decrease in the number of plate granules in the sole.

Denny-Brown and Pennybacker [3] differentiated between the constant irregular tremor of exposed denervated muscle and the coarse involuntary muscular twitching apparent through the skin. The former they called fibrillation; the latter, fasciculation. They expressed the opinion that fibrillations are due to sensitization of the degenerating muscle to the small circulating amounts of acetylcholine, and that fasciculations arise from a pathologic process either in the anterior horn cell or in the peripheral nerve; in view of the pathologic evidence, they suspected the anterior horn cell. Their conclusion as to the origin of fasciculations was based on their observations of single contractions in fixed groups of muscle fibers and was supported by the presence of a recurrent pattern, i. e., the repetition of a certain combination of spikes at definite intervals in the record. In the present studies this repetition of a definite pattern has not been observed. Grund [4] found in 2 cases that spinal anesthesia had no effect on fasciculations. Russel, Odom and McEachern [5] noted no change in the frequency of fasciculations following peripheral nerve block. On the basis of these observations, Tower [6] concluded that the distinction between the site of origin of fibrillations and that of fasciculations is as yet uncertain.

Subsequent studies on nerve root and peripheral nerve block have yielded varying results. Swank and Price [7] noted a decrease of 50 to 65 per cent in the incidence of fasciculations following spinal anesthesia and a decrease following peripheral nerve block in 5 cases, with no alteration of frequency in 1 case. DeJong and Simons [8] observed that peripheral nerve block had no effect on the incidence of fasciculations. A possible explanation for this difference in results is afforded by the observation of Odom, Russel and McEachern [9] that peripheral nerve block had no effect on the incidence of fasciculations in 4 cases but produced a decrease in 2 others. However, in the last 2 cases fasciculations had been elicited previously only by posturing the limb, a procedure which was impossible when the muscles studied were paralyzed.

The results of spinal anesthesia and peripheral nerve block in the present investigations confirm the observations of Grund [4]; Odom, Russel and McEachern,[9] and DeJong and Simon.[8] The selection and placing of patients so as to avoid purposeful and postural movements served to prevent a false reduction in the frequency of fasciculations, as pointed out by Odom, Russel and McEachern.[9] The failure of spinal anesthesia and peripheral nerve block to decrease or abolish fasciculations indicates that the discharges giving rise to these involuntary movements cannot arise in the anterior horn cells, the nerve root or the peripheral nerve proximal to the point of block, for under such conditions blocking of the transmission of impulses should have materially altered the frequency of fasciculations. This opinion receives further support from the increase in

1. Langley, J. N., and Kato, T.: The Physiological Action of Physostigmine and Its Action on Denervated Muscle, J. Physiol. **49**: 410, 1915.

2. Pommé, B., and Noël, R.: La zone de jonction myoneurale dans quelques cas pathologiques, Rev. neurol. **2**: 1, 1934.

3. Denny-Brown, D., and Pennybacker, J. B.: Fibrillation and Fasciculation in Voluntary Muscle, Brain **61**: 311, 1938.

4. Grund, G.: Ueber die Entstehung des fibrillären Muskelzuckungen bei spinalen Amyotrophien, Deutsche Ztschr. f. Nervenh. **145**: 99, 1938.

5. Russel, C. K.; Odom, G., and McEachern, D.: Physiological and Chemical Studies of Neuromuscular Disorders, Tr. Am. Neurol. A. **64**: 120, 1938.

6. Tower, S. S.: The Reaction of Muscle to Denervation, Physiol. Rev. **10**: 1, 1939.

7. Swank, R. L., and Price, J.: Fascicular Muscle Twitchings in Amyotrophic Lateral Sclerosis: Their Origin, Arch. Neurol. & Psychiat. **49**: 22 (Jan.) 1943.

8. DeJong, H., and Simons, D. J.: A Comparative Study of Fibrillation and Tremor, J. A. M. A. **118**:702 (Feb. 28) 1942.

9. Odom, G.; Russel, C. K., and McEachern, D.: Studies of Neuromuscular Disorders: The Myogram, Blood Cholesterinase and Effect of Prostigmine in Myasthenia Gravis and Progressive Muscular Atrophy, Brain **66**:1, 1943.

fasciculations produced by prostigmine during spinal anesthesia or nerve block.

That the effect of curare is peripheral was first demonstrated by Claude Bernard. Kuffler [10] demonstrated that curarine decreases the sensitivity of the end plate to acetylcholine, an effect opposing depolarization and excitation. Since curare acts by blocking impulses at the myoneural junction, the abolition of fasciculations by curarization indicates that they originate at this point or proximal to it. As prostigmine fails to induce fasciculations during curarization, this may be taken as further evidence in favor of this viewpoint. During the studies on curare voluntary movement was possible, so that impulses could be conducted across the myoneural junction. It is quite possible that if fasciculations originate from discharges in the anterior horn cells or from the peripheral nerve proximal to the end plate, these impulses, likewise, could be discharged across the myoneural junction. The failure of acetylcholine and mecholyl (acetylbetamethylcholine) to influence the frequency of fasciculations is most probably due to the rapidity with which the cholinergic substances are destroyed by cholinesterases.

Denny-Brown and Pennybacker [3] pointed out that fasciculations involve neither single fibers nor whole fascicles, but are contractions of a group of fibers between these two extremes. This group of fibers, they concluded, is a motor unit. It is not possible to reconcile the contraction of all the muscle fibers innervated by a single neuron with a purely peripheral mechanism. While it is known from the work of Masland and Wigton [11] that fasciculations induced by prostigmine result in an antidromic impulse along the motor nerve, this effect cannot be considered as a possible basis for the timing of the simultaneous contraction of many individual fibers, for, among other reasons, antidromic impulses to the anterior horn cells would be blocked by spinal anesthesia and nerve block. While the timing mechanism permitting the simultaneous contraction of many fibers is not evident, the continuation of these simultaneous contractions when the muscle fibers are segregated from the central nervous system by pharmacologic block and their cessation under curarization constitute evidence, nevertheless, that their origin is peripheral, and in the region of the myoneural junction.

Although both fasciculations and fibrillations originate in the same vicinity, it is not possible, at least at present, to consider them as similar manifestations. Fibrillations occur only in completely denervated muscles, while fasciculations are seen in the absence of complete denervation.

SUMMARY

Spontaneous muscular fasciculations are not affected by spinal anesthesia or peripheral nerve block. Under these conditions the increase in fasciculations produced by prostigmine is likewise unaffected. Curare abolishes spontaneous fasciculations and prevents the induction of fasciculations by prostigmine. Fasciculations originate, therefore, not in the anterior horn cells but in the region of the myoneural junction.

111 North Forty-ninth Street.
1025 Walnut Street.

10. Kuffler, S. W.: Specific Excitability of the End-plate Region in Normal and Denervated Muscle, J. Neurophysiol. **6**: 99, 1943.

11. Masland, R. L., and Wigton, R. S.: Nerve Activity Accompanying Fasciculation Produced by Prostigmin, J. Neurophysiol. **3**:269, 1940.

TUMOR OF THE ACOUSTIC NERVE WITHIN THE PETROUS BONE

OPERATIVE REMOVAL

LEO J. ADELSTEIN, M.D., AND FRANK M. ANDERSON, M.D.
LOS ANGELES

Neoplasms arising from the sheath of the acoustic nerve are not uncommon; they comprise from 8 to 10 per cent of all intracranial tumors. Ordinarily these growths are closely applied to the portion of the nerve extending from the internal auditory meatus to the pons, and frequently there is close attachment of the tumor to the bony wall of the meatus, with erosion of that structure to a variable extent.

The case reported here is of unusual interest because the tumor arose completely within the petrous bone and did not present itself to view in the usual location. Rather, it eroded the bone extensively and was disclosed at operation as a bulging mass on the posterior surface of the petrous pyramid, completely covered by the greatly thinned bony wall and the overlying dura.

A review of the literature did not disclose the report of such a tumor except for the microscopic growths encountered in autopsy material on serial section of the petrous pyramid.

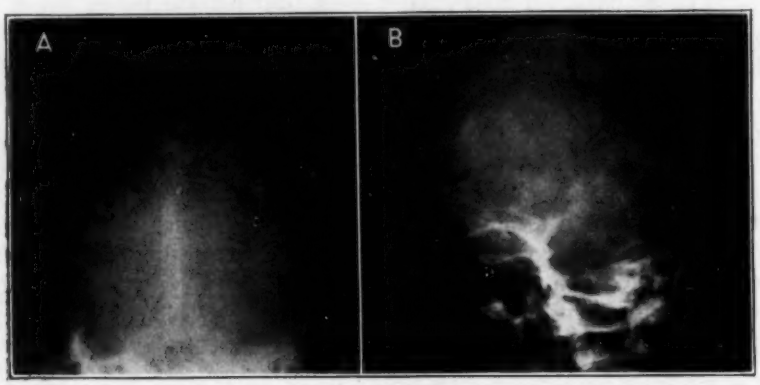


Fig. 1.—Roentgenograms of the skull, indicating (*A*, Towne position) extensive erosion of the ridge of the right petrous bone and (*B*, Stenver position) erosion in the region of the right internal acoustic meatus.

REPORT OF A CASE

History.—A high school girl aged 15, white, six years prior to her first admission to the hospital noted the gradual onset of tinnitus and deafness in the right ear. The tinnitus never became severe, but the impairment in hearing increased to a loss of at least 50 per cent and was noticeable to the patient. For this reason tonsillectomy was performed, a procedure which did not alter the course of the symptoms.

Approximately three years before admission to the hospital weakness of the right side of the face was observed. This was progressive, and within a year this side of the face became entirely paralyzed. The patient was unable to draw her mouth to the right or to raise her right eyebrow. She could partially close the eyelid by strongly closing the left eye.

There were no other subjective complaints; headache had at no time been present, and dizziness and unsteadiness in gait were never in evidence. In fact, the patient had been under observation for some time before her admission for what was thought to be Bell's palsy of the ordinary type.

Examination.—On her admission to the hospital, on Jan. 3, 1940, examination showed that the patient was well developed, alert and cooperative. General physical inspection revealed no abnormalities of any sort except obvious paralysis of the right side of the face. Routine examination of the throat, ears and chest revealed nothing abnormal. Neurologic examination disclosed brief nystagmus on full left lateral gaze, slight hypesthesia over the distribution of the second division of the trigeminal nerve on the right side and total paralysis of the right side of the face, with loss of the sense of taste over the anterior two thirds of the tongue on the same side. Faradic stimulation of the right facial nerve provoked no contraction of the facial muscles.

Audiometric examination disclosed perception deafness in the right ear, with loss of approximately 50 per cent in all ranges. Cold caloric stimulation of the right ear elicited no response in the horizontal semicircular canal and a delayed reaction in the vertical canals. The left labyrinth appeared normal.

Cerebellar signs were minimal; there were slight dysdiadokokinesis and asynergy in the right upper extremity, but these signs were not detected in the leg. The deep

From the Neurosurgical Service of Dr. Carl W. Rand, Los Angeles County General Hospital, and the Department of Neurological Surgery, University of Southern California School of Medicine.

reflexes were somewhat greater in the right extremities than in the left; there were no pathologic reflexes.

Spinal puncture revealed a pressure of 260 mm. of water, with normal dynamics and negative serologic reactions. Roentgenograms of the skull (fig. 1 *A* and *B*), taken in the Towne and Stenver positions, showed

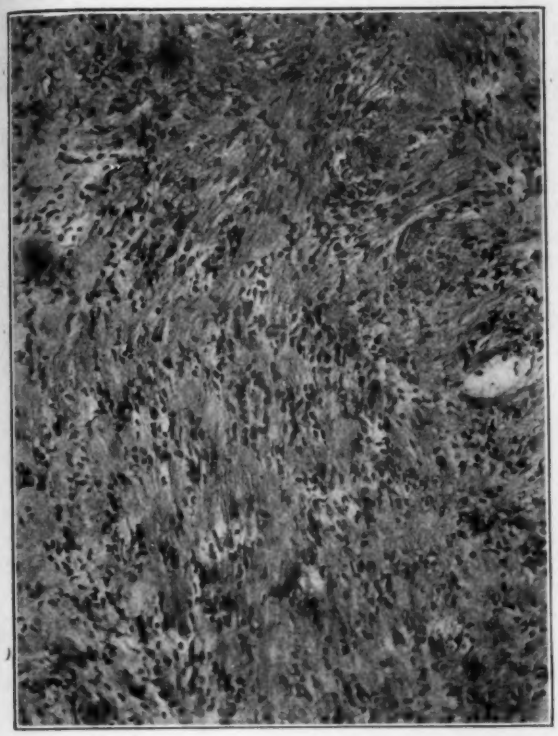


Fig. 2.—Acoustic tumor; hematoxylin and eosin stain; × 120.

erosion of the ridge of the right petrous bone in the region of the internal acoustic meatus.

Diagnosis.—The diagnostic impression before operation was that of an acoustic neuroma or a cholesteatoma in the right cerebellopontile angle.

Operation.—On January 19 a midline cerebellar incision was outlined from the inion to the third cervical spine, and the suboccipital muscles were widely retracted from the midline. The bony floor of the posterior fossa was then removed superiorly up to the torcular Herophili and inferiorly down to, and including, the posterior half of the ring of the foramen magnum. The dura over the cerebellum was tense; so the posterior horn of both the right and the left lateral ventricle was tapped, with release of the intracranial tension. The dura over the cerebellum was then opened, and the straight sinus was tied with black silk. The cisterna magna was emptied and a large amount of fluid released; this permitted a careful and easy inspection of the right cerebellopontile angle. The seventh and eighth cranial nerves on the right side were easily identified in their peripheral distribution, and no tumor was seen. With gentle retraction of the right cerebellar lobe, the base of the skull was searched carefully, and in the region of the right petrous bone a large, hard eminence was discovered, an observation which indicated at once an underlying tumor. The bony shell which presented itself was opened with a small forceps, and as large an amount of tumor tissue as possible was removed with the aid of a small curet. A piece of the bony shell together with tumor tissue was taken for examination in order to determine their exact relation. The wound was given a thorough toilet so that at the close of the operation the operative site was entirely dry. The wound was then closed carefully in layers with black silk. The condition of the patient at the end of the operation was fair.

Postoperative Course.—The patient's convalescence was uneventful. The appearance of the face remained the same as before operation, partial closure of the right eye being possible, as it was before the operation. The deafness of the right ear was of course complete.

Pathologic Examination.—Microscopic study of the tissue removed at operation disclosed a rather dense fibrous stroma, with some tendency to bandlike arrangement and pseudopalisading of cells (fig. 2). The connective tissue had in several areas undergone a mild degree of hyalinization. One of the sections demonstrated the thin, closely approximated plate of bone which had been removed in gaining access to the tumor. The diagnosis was that of neurofibroma.

Three months later (March 25) a spinal accessory-facial nerve anastomosis was performed on the right side, the descendens hypoglossi nerve being sutured to the distal end of the accessory nerve (fig. 3).

Approximately three months after the nerve anastomosis, that is, at least two years after the paralysis of the face became complete, slight movement could be detected at the corner of the mouth on strong effort. Within the next two months considerable motion became possible, and with constant practice and physical therapy the patient has, after almost two years, attained good use of the face, with an excellent functional result.

There have been no symptoms of any nature to suggest recurrence of the tumor, and the patient is entirely free from symptoms except for deafness in the right ear.

Fig. 3.—Photograph of the patient before anastomosis of the spinal accessory and the facial nerve on the right side.

COMMENT

It is probable that the majority of acoustic neuromas arise from the portion of the nerve within the petrous bone, or in close approximation to the internal acoustic meatus. However, growth usually takes place in the direction of least resistance, i. e., medially, so that the tumor

presents itself in the posterior fossa adjacent to the pons and the cerebellar hemisphere; this makes the precise point of origin difficult of determination. Many authors have described neoplasms of the eighth nerve confined entirely to the bony canal, but such growths have without exception been small tumors, the size of a pea or less, which produced no important clinical symptoms and were discovered post mortem on section of the petrous bone. Cushing,[1] in his treatise on tumors of the acoustic nerve, cited several instances of this type, as did Hardy and Crowe,[2] Fowler [3] and others.

Fig. 4.—Photograph taken two years after operation, indicating the patient's ability to use the facial muscles.

The present case is unique in that the tumor arose within the internal auditory canal and grew to such size that it produced definite cerebellar signs, together with slight impairment of function of the trigeminal nerve, diminution of the deep reflexes on the opposite side of the body and increase in intracranial pressure, without presenting medially through the meatus. Rather, growth took place by expansion and erosion of the bony canal itself, a feature undoubtedly made possible by the youth of the patient, who was 15 years of age at the time of operation, and this extradural bulge evidently produced sufficient compression of the cerebellar peduncles and the brain stem to create the clinical picture.

The patient had no antecedent head trauma of any sort. The theory that trauma, with perhaps a minor fissure fracture of the petrous bone, might be a factor in the origin of these tumors was tentatively advanced by Fowler.[3]

The spinal accessory–facial nerve anastomosis, although not performed until two years after paralysis of the face was complete, gave an excellent clinical result. When the face is in repose, there is practically no asymmetry, though this was very noticeable before operation, and, as a result of constant practice, the face shows remarkable ability to assume an almost symmetric smile (fig. 4). Strangely, the patient can draw back the corners of the mouth more completely by thinking of this act, as though the facial nerve were intact, than she can by elevating the shoulder (function of the accessory nerve). She has never regained the ability to wrinkle the forehead by raising the eyebrow on the affected side, although she frowns normally.

SUMMARY

In the case of a 15 year old girl who showed total paralysis of the right side of the face and high grade loss of function of the acoustic nerve associated with slight cerebellar signs on the same side, operation disclosed a neurofibroma which lay completely within the petrous pyramid and produced a bulge of this structure into the posterior fossa. The tumor was removed, and later the spinal accessory and facial nerves were anastomosed, with an excellent clinical result. Tumors of such size confined entirely to the intrapetrous portion of the acoustic nerve are exceedingly uncommon.

1930 Wilshire Boulevard.

1. Cushing, H.: Tumors of the Nervus Acusticus, Philadelphia, W. B. Saunders Company, 1917.

2. Hardy, M., and Crowe, S. J.: Early Asymptomatic Acoustic Tumors, Arch. Surg. **32**:292 (Feb.) 1936.

3. Fowler, E. P.: Acoustic Tumors Within the Internal Auditory Meatus, Laryngoscope **46**:616 (Aug.) 1936.

ANEURYSM OF THE VERTEBRAL ARTERY

REPORT OF A CASE IN WHICH THE ANEURYSM SIMULATED A TUMOR OF THE POSTERIOR FOSSA

H. E. YASKIN, M.D., AND BERNARD J. ALPERS, M.D.
PHILADELPHIA

Large aneurysms involving the vertebral arteries are rare. For this reason it seems desirable to record a case of a particularly large aneurysm which gave signs of a tumor of the posterior fossa, as well as to review the recorded cases with the object in mind of elucidating a group of signs which can be regarded as characteristic of the disorder.

Since Cruveilhier[1] published his case of aneurysm of the vertebral artery in 1835, 72 cases of aneurysm of the intracranial portion of the vertebral arteries have been reported. Many of the earlier papers merely cite the occurrence of the aneurysm and include few, or no, clinical and postmortem observations.

REPORT OF CASE

History.—W. E., a man aged 44, was admitted to the Jefferson Medical College Hospital on Oct. 14, 1942 with symptoms of four months' duration. At the onset of his illness he experienced left frontal headache, which radiated from the left suboccipital region. These attacks of pain became progressively worse and at times were associated with nausea and vomiting. Two months before admission he had taken 4 tablets (1.2 Gm.) of acetylsalicylic acid and 4 drachms (15.5 Gm.) of bromo-seltzer daily to relieve his discomfort. At that time he found that he collided with people on his left while walking on the street. When he tried to turn his head to either side, he experienced a sharp, lancinating pain in the back of his neck. He had episodes of momentary confusion and dizziness. His speech became thick, and on a few occasions he had difficulty in swallowing. He suffered from unsteadiness of gait, which became more pronounced with time. In the two weeks prior to hospitalization he believed his vision had become blurred, and he had intermittent diplopia. On the day before admission, while driving his automobile, he suffered a lapse of consciousness.

At the age of 2 years he had had an attack of poliomyelitis, with resultant atrophy of the right lower extremity. At the age of 29 he suddenly lost vision in the right eye. This condition gradually subsided, with return of vision in the affected eye. In 1934 he contracted gonorrhea. Since 1936 he had had attacks of dyspnea and precordial distress. In 1938 he had a severe injury to the head.

Examination.—The patient was poorly nourished and showed evidence of considerable recent loss in weight. He was mentally sluggish and had difficulty in concentration and attention. There was partial loss of memory, with impairment of powers of calculation and recall. His speech was thick and slightly slurred. He walked with a reeling, ataxic gait and veered frequently to the left. He fell backward and to the left in the Romberg test. The pupils were irregular and reacted sluggishly to light. The optic disks were grayish and well defined. The retinal arteries were spastic and sclerosed, especially in the left eye. In the right eye there were evidences of old chorioretinitis. The movements of the extraocular muscles were full. On looking to the left he had rotary clockwise nystagmus. There were hypermetria and dyssynergia of both upper extremities, the greatest degree of cerebellar dysfunction being manifested in the left arm and hand. Truncal ataxia was pronounced. The deep tendon reflexes on the left were hyperactive. There were no pathologic reflexes. The abdominal reflexes were absent. Hypalgesia to pinprick was present over the anterior portion of the left side of the thorax and the left arm. A clearly defined sensory level could not be mapped out. Position sense and vibratory perception were intact. When his head was passively flexed or rotated to the right he experienced severe pain in the occipital and cervical regions. He had flaccid paresis of the right lower extremity with focal muscular wasting and areflexia, the result of his previous attack of poliomyelitis.

Percussion revealed that the heart was enlarged to the left axillary line. A presystolic mitral murmur was present. The liver was enlarged and was palpable 2 fingerbreadths below the costal margin. The blood pressure was 140 systolic and 110 diastolic.

Because of the toxic, torpid, confusional mental state and the history of excessive intake of bromo-seltzer, a diagnosis of bromide intoxication was made. The existence of a neoplasm of the left posterior fossa, involving the cerebellar hemisphere, vermis and medullary centers and pathways on that side, was likewise suspected.

Laboratory Studies.—On admission the bromide level in the blood was 90 mg. per hundred cubic centimeters. Urinalysis showed normal constituents. The blood count revealed secondary anemia. The Wassermann and Kahn reactions of the blood and the spinal fluid were negative. Lumbar puncture yielded xanthochromic fluid, under an initial pressure of 116 mm. of water; the spinal fluid contained 10 cells per cubic millimeter, and the total protein content was 116 mg. per hundred cubic centimeters. Studies of the chemical constituents of the blood gave normal values.

Roentgenograms of the chest showed enlargement of the heart to the left and a hypertensive configuration. The aorta was enlarged and tortuous. Roentgenograms of the skull and the cervical vertebrae revealed small calcified areas in the right parietal area of the skull. The pineal gland was calcified and in normal position. The electrocardiographic tracings revealed a conduction

From the Department of Neurology, Jefferson Medical College of Philadelphia.

1. Cruveilhier: Anatomie pathologique du corps humain, Paris. J. B. Baillière, 1835, vol. 2, no. 28, plate 3.

Clinical Cases of Aneurysm of Vertebral Artery Reported in the Literature

Author	Age, Yr.	Sex	First Symptoms: Nature	First Symptoms: Duration	Other Symptoms	Signs	Spinal Fluid	Roentgenogram	Observations at Necropsy
Cruveilhier [1] (1835)	60	M	.....	.....	.....	.....	.....	.....	Aneurysm of right vertebral artery
Neill [3] (1849)	..	M	Convulsions (?)	.....	.....	.....	.....	.....	Aneurysm of right vertebral artery; calcareous deposit in wall of sac
Lorne [4] (1869)	19	M	Signs of meningeal irritation	Acute onset	.....	.....	.....	.....	Ruptured aneurysm of left vertebral artery; subarachnoid hemorrhage
Echeverria [5] (1870)	67	M	Dizziness; dysphagia; inability to protrude tongue	Few months; sudden death	Weakness of limbs, with stiffness and rigidity	Inability to protrude tongue or to swallow; extreme vertigo on attempted locomotion	.....	.....	Ruptured aneurysm of right vertebral artery; atheroma of coats of vessels at base of brain; subarachnoid hemorrhage
Sevestre [6] (1872)	45	M	Severe headache (especially occipital) and prostration	15 days; recurrent attacks and sudden death	Paralysis of lower limbs	Flexion and paralysis of limbs; distention of bladder	.....	.....	Ruptured aneurysm of left vertebral artery; slight atheromatous changes in coats; second pea-sized, unruptured aneurysm of left vertebral artery; subarachnoid hemorrhage
Schultze [7] (1875)	56	M	Convulsive tic of muscles of left side of face except frontalis	12 months	.....	Progressive paresis of muscles of left side of face except frontalis	.....	.....	Unruptured, "cherry stone-sized" aneurysm of left vertebral artery in intimate association with 7th and 8th cranial nerves on left
Osler [9] (1880)	36	M	Sudden collapse and death	.....	.....	.....	.....	.....	Ruptured small aneurysm of left vertebral artery; subarachnoid hemorrhage; sclerotic walls; endarteritis
Möser [11] (1884)	61	M	Progressive bulbar palsy	12 months	.....	Signs of progressive bulbar palsy; four days before death bruit on each side between mastoid and vertebral column	.....	.....	Fusiform aneurysm of left vertebral artery, measuring 20 by 12 mm.; medulla compressed and distorted; fatty degeneration of intima
Ladame and von Monakow [14] (1900)	..	..	.....	.....	.....	General motor incoordination; complete analgesia of right side of body; diplopia; irregular pulse	.....	.....	Saccular aneurysm of right vertebral artery, size of pigeon's egg; compression of left side of pons, cerebellum and medulla; vessels atheromatous
Hedinger [15] (1905)	50	M	Violent headache, with vomiting and disturbance of consciousness	14 days before death	.....	Left hemiplegia of 8 years' duration	.....	.....	Unruptured aneurysm of right vertebral artery; localized syphilitic periarteritis of aneurysm
Rindfleisch [16] (1905)	51	F	Severe suboccipital headache and feeling of anxiety	6 days, followed by deep stupor	Headache for 3 yr.	Deep stupor; fundi showed hemorrhages and edematous disks; sudden deep coma; slow pulse	Initial pressure 32 mg. Hg; bloody fluid	.....	Ruptured aneurysm, size of bean, in right vertebral artery; subarachnoid hemorrhage
Beadles [17] (1907)	65	F	Gradual development of palsy of right side of face and right hemiplegia, with progressive bulbar palsy	1 year	Psychosis of organic type, with cerebral arteriosclerosis	Paralysis of right side of face and right limbs; bulbar palsy; partial deafness	.....	.....	Unruptured, calcified aneurysm, size of pea, in left vertebral artery; pressure against roots of nerves in cerebellopontile angle; atrophy of tissue on left side of medulla; recent hemorrhage in left cerebral hemisphere; arteriosclerosis
Ruston and Southard [18] (1906)	69	F	Sudden, boring suboccipital pain, with projectile vomiting	19 days	Drowsiness for 1 yr., dull ache in suboccipital region between acute episodes; sudden death from respiratory failure	Slow pulse	.....	.....	Fusiform aneurysmal dilatation of both vertebral arteries; miliary cerebral aneurysms with rupture
Longcope (1909)	57	M	Headache	6 years	More severe headache before admission; episode of unconsciousness	Retraction of head; paralysis of right lower extremity; delirium; episode of unconsciousness	Bloody	.....	Ruptured aneurysm of vertebral artery, with subarachnoid hemorrhage
Wichern [20] (1911)	42	M	Headache and stiffness of neck; sudden coma before admission	2 months	Coma with stiffness of neck on admission	Stiffness of neck	Bloody	.....	Ruptured aneurysm of left vertebral artery, size of pea; thickening of vessels

Wichern [20] (1911)	42	M	Headache and stiffness of neck; sudden coma before admission	2 months	Coma with stiffness of neck on admission	Stiffness of neck	Bloody	.....	Ruptured aneurysm of left vertebral artery, size of pea; thickening of vessels
Bailey [21] (1913)	37	M	Stiffness of neck; weakness of right arm	2-3 years	On admission, severe shooting pains in back of neck, radiating to head, and paresthesias of right extremities	On admission, flaccid quadriplegia; sensory level to 2d cervical dermatome	.....	.....	Aneurysm of right vertebral artery, compressing high cervical part of cord; endarteritis
Weidman [10] (1915)	40	M	Chills and sweats, followed by unconsciousness	1 hour	Recovery of consciousness, followed by irrationality and somnolence; convulsions and death five days later	Signs of meningeal irritation and attacks of opisthotonos; papilledema in left eye with hemorrhages in fundus	Bloody	.....	Ruptured aneurysm of right vertebral artery; proliferative endarteritis
Hedinger [22] (1917)	47	F	Recurrent pain in back of neck and shoulders after fall	4 years	Sudden, severe pain in back of neck on day before sudden death	.....	.....	.....	Ruptured aneurysm of left vertebral artery; subarachnoid hemorrhage
Kerppola [23] (1919)	28	M	Headache; pressure in head and attacks of vertigo	Weeks	.....	.....	.....	.....	Ruptured anurysm of right vertebral artery
Wells [25] (1922)	54	M	Episodic headaches	8 to 10 years	Syncopal attacks for 3 yr.; pain in face and teeth for 2 yr.; ataxia, weakness, incontinence, progressive bulbar palsy, vertigo and roaring in ears 1-2 mo.	No paralysis noted	.....	.....	Unruptured saccular aneurysm of left vertebral artery (35 by 34 by 30 mm.), with compression of pons, cerebellum, medulla and roots of 6th to 9th cranial nerve
Packard and Zabriskie [26] (1925)	50	M	Sudden occipital headache; pain in back and legs and drooping of left eyelid	2 weeks	Sudden death of apoplexy 2 wk. after onset of symptoms	Paralysis of left 3d, 4th and 6th cranial nerves, with fixed left pupil	Yellowish fluid, under moderate pressure; 50 cells per cu. mm.; Wassermann reaction negative; no increase in globulin	.....	Ruptured aneurysm of left vertebral artery, with subpial hemorrhage
Conway [27] (1926)	40	F	Pain in left side of face; subjective vertigo and unsteady gait, associated with episodic attacks of pain	2 years	Severe pain in back of neck and failing vision for 1 mo.; stupor	Palsy of right side of face, paresis of left limbs; weakness of both external rectus muscles; bilateral optic neuritis	Abundant red blood cells in fluid	.....	Unruptured aneurysmal tumor of left vertebral artery, with invasion of cerebellum; atheromas present
Keegan and Bennett [28] (1931)	50	F	Intense pain in suboccipital region and neck, followed by convulsions and coma; recovery	8 years	Ataxia and weakness 7 yr. after onset, with medullary paralysis 1 yr. later	Signs of meningeal irritation at initial attack; ataxia and nystagmus 7 yr. later	Bloody spinal fluid at initial attack; clear fluid 7 yr. later; serologic reactions negative	.....	Unruptured, oval aneurysm, 2.5 cm. in diameter, of left vertebral artery
	56	M	Coma and death	4-6 hours	.....	.....	Bloody fluid; serologic reaction negative	.....	Ruptured aneurysm of right vertebral artery, 5-10 mm. in diameter, with basilar subarachnoid hemorrhage
Currier and Davis [9] (1936)	45	F	Sudden onset of severe headache and pain in neck	2 months	Attacks of unconsciousness, with recovery; personality change after first coma; sudden death	Negative results of neurologic examination	Bloody fluid after first coma, becoming xanthochromic; serologic reactions negative	.....	Ruptured aneurysm of right vertebral artery, 9 by 4 mm., with subarachnoid hemorrhage
Dial and Maurer [29] (1937)	2	M	Trauma to head, with fracture of skull and unconsciousness; sudden coma 5 days after recovery	Coma 5 days after return of consciousness	Signs of medullary failure with coma	Signs of meningeal irritation and medullary collapse	Bloody fluid	Fracture of left frontal bone	Ruptured aneurysm of right vertebral artery
Maass [30] (1937)	35	M	Severe headache	1 day before death	Unconsciousness	Positive Babinski sign	Bloody fluid; positive Wassermann reaction	.....	Small ruptured aneurysm at junction of both vertebral arteries with basilar artery; syphilis
	?	F	Coma and death	.....	.....	.....	Bloody	.....	Small ruptured aneurysm of right vertebral artery; syphilis
Dandy [24] (1937)	63	F	Progressive deafness and tinnitus in left ear	1 year	Year after onset, attacks of dizziness with nausea and vomiting with any quick movement; in sequence, unsteadiness of gait and progressive deafness	Unsteadiness of gait; diminution of left corneal reflex	.....	.....	Operation revealed aneurysm under left 8th cranial nerve; aneurysm continuous with left vertebral artery

Clinical Cases of Aneurysm of Vertebral Artery Reported in the Literature—Continued

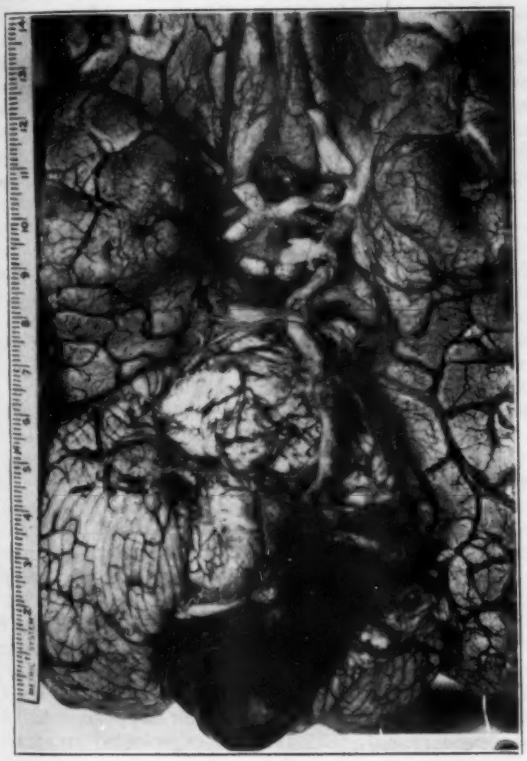
Author	Age, Yr.	Sex	First Symptoms: Nature	First Symptoms: Duration	Other Symptoms	Signs	Spinal Fluid	Roentgenogram	Observations at Necropsy
Boyd and Werblow [21] (1937)	57	F	Sudden excruciating pain in right lumbar region (dissecting aortic aneurysm); choking sensation in neck, with nausea and vomiting	1 week	Initial symptoms merged into stupor; paralysis of left extremities and left side of face; convulsion and death	Signs of stupor; blood pressure 200/75; arteries of fundi sclerotic	.....	.....	Unruptured fusiform aneurysmal dilatation of terminal portion of left vertebral artery; compression of left cerebellar hemisphere by aneurysm; atherosclerosis; dissecting aortic aneurysm, with coarctation of aorta
Loder [22] (1938)	67	M	Paroxysms of sharp pain behind right ear, radiating down neck, especially when head was turned to left	1 year	15 yr. before last illness, vertiginous, syncopal attack with residual weakness of left side of face and left hand, which cleared; with last attack, diminished hearing in right ear, ataxia and progressive bulbar palsy	Palsy of left side of face, ataxia; generalized cerebellar dysfunction, especially on right; progressive signs of bulbar palsy toward end of clinical course	.....	.....	Unruptured vertebral ovoid aneurysmal mass of right artery, compressing adjacent portion of medulla, cerebellar hemisphere and cranial nerves, 7th to 12th inclusive, on same side
Bassoe [23] (1939)	31	F	Headache; pain over vertex, occiput and back of neck	6 months	1914: delirium; 1916: cramps in legs, dizziness; 1937: weakness in left side of body; pain about left ear, radiating down to left side of body	1914: stiff neck; 1916: hypalgesia on right side of body; 1937: left hemiparesis	1914: fluid bloody and under increased pressure; 1916: fluid clear; 1937: fluid clear; 7 cells per cu. mm.; Wassermann reaction negative; total protein 99.6 mg. per 100 cc.	.....	Saccular aneurysm of left vertebral artery, compressing adjacent portions of pons and medulla; syphilitic arteritis; multiple smaller aneurysms of basilar artery; syphilitic aortitis
	52	M	Dizziness and severe headache	5 years	2 yr. after onset, numbness of left side of body, paresis of left leg; 5 yr. after onset, severe vertiginous spells and convulsions	Bilateral pyramidal tract signs; hypalgesia on left side of body; thick speech; ataxia of right hand	Fluid clear; 7 cells per cu. mm.; Wassermann reaction negative	.....	Operation revealed "vascular aneurysm with tremendous enlargement of left vertebral artery"
Richardson and Hyland [25] (1941)	49	M	Tinnitus in left ear and occipital headache	2 years	Psychosis for 10 yr.; deafness of left ear; numbness of left side of face; diplopia; ataxia	Left hemiparesis; nystagmus on left lateral gaze; palsies of left 3d, 5th, 6th, 7th and 8th cranial nerves	.....	Venticulogram showed marked dilatation of ventricular system	Dumbbell-shaped, nodular aneurysm, 5 by 3 by 2 cm., compressed against anterolateral aspect of left side of pons and filling cerebellopontile angle; attached to trunk of right vertebral artery
Globus and Schwab [26] (1942)	50	F	Severe drawing pains in left side of neck and episodic dizziness	6 years	Periodic headaches; difficulty with speech and deglutition; generalized weakness; insomnia	Slight left hemiparesis; broad-based gait; bilateral papilledema and postneuritic optic atrophy; horizontal nystagmus bilaterally; palatal paralysis	Clear; 3 cells per cu. mm.; initial pressure 108 mm. of water; total protein 64 mg. per 100 cc.; Ayala index 5.5	Roentgenogram negative; ventriculogram: marked dilatation of lateral ventricles, with right slightly larger than left	Unruptured aneurysm (1.5 by 1 by 0.75 inch) of left vertebral artery, compressing inferior surface of cerebellum and left side of medulla and pons; extension into foramen magnum; proliferative endarteritis
Yaskin and Alpers (1943)	44	M	Left suboccipital pain and left frontal headache	4 months	Vertigo for 3 yr. Last 4 mo.: bromidism; ataxic gait, with veering to left. Vertiginous attacks; change in position of neck caused severe nuchal pain; thick speech; occasional dysphagia	Mental torpidity; left rotary nystagmus; bilateral cerebellar dysfunction of limb and trunk, more marked on left; pyramidal tract signs on left; hypalgesia to 2d dorsal level on left	Xanthochromia; initial pressure 160 mm. of water; total protein 116 mg. per 100 cc.; serologic reaction negative	.....	Large, unruptured saccular aneurysm of left vertebral artery, with regional compression of medulla, cerebellum and upper cervical part of cord; generalized atherosclerosis

deformity of the entire ventricular complex, which indicated a severe grade of myocardial impairment. There was pronounced left axis deviation. The visual fields were normal.

Audiometric tests showed a 29 per cent loss of hearing for speech in the left ear and an 18 per cent loss in the right ear. In the caloric tests the most striking observation was the absence of past pointing on stimulation of all canals on the left side, an indication of the possible presence of a lesion in the cerebellar nuclei of the same side.

The electroencephalographic tracings showed poorly developed abnormal waves over the right frontal lobe.

Course of Illness.—The bromidism was treated with large doses of sodium chloride, hydration and intramuscular injections of desoxycorticosterone acetate (2.5 mg. twice a day). After one month the bromide



Large saccular aneurysm of the left vertebral artery, with regional compression of the medulla and cerebellum.

content of the blood was too low to read. The neurologic picture was still characterized by nystagmus, cerebellar dysfunction, especially in the left extremities, and suboccipital pain on rotation of the neck. In addition, paresis had developed in the left limbs, particularly in the arm, with hyperreflexia in these members. A sensory level for pinprick was present at the second cervical dermatome on the left side. Because of the pain in the neck and the sensory level, a tumor in the high cervical portion of the cord, projecting into the posterior fossa, was suspected. Lumbar puncture, performed on November 12, revealed yellow-tinged fluid, under an initial pressure of 200 mm. of water. The total protein of the spinal fluid measured 69 mg., the sugar 67 mg. and the chlorides 709 mg. per hundred cubic centimeters.

The patient's poor physical condition, together with the development of a severe infection of the urinary tract, delayed the consideration of an exploration of the posterior fossa. On November 24 symptoms of respiratory collapse developed, and he died.

Necropsy.—The scalp, skull and meninges were normal. The brain weighed 1,500 Gm. The cerebral hemispheres were symmetric in size and shape. Inspection of the base of the brain revealed that the left vertebral artery was tremendously dilated and coiled on itself to form a saccular tumor mass with a smooth surface (figure). The aneurysm measured 6.5 cm. in length, 3 cm. in depth and 2 cm. in diameter. It had not ruptured, and the entire lumen contained an antemortem thrombus. An excavation extending into the adjacent basilar portion of the left cerebellar hemisphere and the left side of the vermis had been made by the aneurysm, and the medulla was compressed and displaced to the right. The upper cervical portion of the cord was compressed to a lesser degree. The right vertebral artery was hypoplastic and measured about 1 mm. in diameter. The remaining vessels of the circle of Willis showed arteriosclerotic thickening and formation of plaques. There were no other aneurysms of the intracranial arteries.

Diagnosis.—The anatomic diagnoses were saccular aneurysm of the left vertebral artery, with a massive antemortem thrombus; regional compression of the medulla, cerebellum and high cervical portion of the cord; pronounced generalized atherosclerosis; cirrhosis of the liver; acute necrotizing cystitis; penetrating abscess of the fundus of the urinary bladder, and calculus of the pelvis of the right kidney.

The cause of death was aneurysm of the left vertebral artery with medullary compression.

SURVEY OF LITERATURE

Allusion has already been made to the rarity of aneurysm of the vertebral arteries. This is emphasized by the statistics of McDonald and Korb,[2] who, from 407 articles published before Jan. 1, 1938, compiled 1,125 cases of saccular aneurysm of the arteries at the base of the brain, verified by necropsy or operation. They found that in a series of 1,023 cases of aneurysm the location of which had been verified, only 59 were reported in which the vertebral arteries were involved. We were able to find 8 more verified cases of aneurysm of the vertebral arteries recorded since 1938, including the case here reported, the total number of verified cases now being 67.

Cruveilhier,[1] in 1835, reported on an aneurysm which involved the right vertebral artery. It occurred in a man aged 60 who had several aortic aneurysms. The pons was deeply depressed. Neill[3] reported a case of ruptured aneurysm of the right vertebral artery in "a man who suffered with affection of the nervous system, I think epilepsy." The walls of the sac were thickened by calcareous deposits in the middle coat of the artery. Lorne[4] observed a ruptured aneurysm of the left vertebral artery in a boy who had died after an acute

2. McDonald, C. A., and Korb, M.: Intracranial Aneurysms, Arch. Neurol. & Psychiat. **42**: 298 (Aug.) 1939.

3. Neill, J.: Contribution to Pathological Anatomy, Am. J. M. Sc. **18**:122 (July) 1849.

4. Lorne: Anévrysma de l'artère vertébrale, Bull. Soc. anat. de Paris **44**:455 (Nov.) 1869.

meningeal syndrome. Echeverria[5] described the case of an elderly man who had suffered from attacks of dizziness, inability to protrude the tongue, dysphagia and difficulty in locomotion for months before his death. Examination revealed dysarthria and partial paralysis of the limbs, which were stiff and rigid. The patient died suddenly while straining at stool. Necropsy revealed a ruptured aneurysm of the right vertebral artery. The vertebral arteries and those at the base of the brain were in a state of fatty and atheromatous degeneration. The ninth, tenth, eleventh and twelfth cranial nerves on the right side were compressed by the aneurysmal sac, a condition explaining the paralysis of the tongue and the dysphagia. Sevestre[6] reported a case of a man of middle age who had recurrent attacks of prostration associated with severe headache, especially in the occipital region. In one of these attacks both lower extremities were paralyzed. At necropsy subarachnoid basilar hemorrhage was prominent. In the left vertebral artery were two small aneurysms approximately 0.5 cm. in diameter. Only one of these was ruptured.

Many of the cases reported concern small aneurysms, such as that of the left vertebral artery, recorded by Schultze,[7] which was the size of a cherry stone and was unusual in producing a prominent convulsive tic involving the musculature of the left side of the face. In this case death resulted from a pulmonary disorder. Necropsy showed an aneurysm near the opening of the porus acusticus internus and in intimate relationship with the facial and auditory nerves. A number of the small aneurysms of the vertebral artery were discovered at necropsy after sudden death from subarachnoid hemorrhage. Osler[8] reported such a case, in which a ruptured aneurysm was observed in a young man who had previously been free of cerebral symptoms. Currier and Davis[9] and Weidman[10] likewise reported cases of a ruptured vertebral aneurysm. In their cases pain in the neck was prominent shortly before death. Möser[11] recorded a case of aneurysm of the left vertebral artery which occurred in a man aged 61, who suffered from mitral endocarditis. Symptoms of a progressive bulbar lesion had existed for a long time. Four days before death a loud murmur was heard on each side between the mastoid region and the vertebral column. At necropsy the aneurysm, which was fusiform and measured 20 by 12 mm., was observed to compress the anterior surface of the medulla. With this case, Möser reported 2 cases in which an aneurysm of the vertebral artery, noted post mortem, had not produced symptoms.

Eppinger[12] also reported a case of aneurysm of the right vertebral artery in a woman aged 30. The aneurysm was 6 mm. in diameter and had caused no known neurologic symptoms. In 1894 von Hofmann[13] published an analysis of 78 cases of intracranial aneurysm, in 10 of which the lesion occurred in the vertebral artery. In all 10 of these cases the aneurysm had ruptured and caused sudden death but had not been observed clinically. Ladame and von Monakow[14] observed an aneurysmal dilatation of the left vertebral artery, "the size of a pigeon's egg," which had produced degeneration of the pons, cerebellum, olive, pyramid and left auditory nerve. The fifth, sixth, ninth and tenth cranial nerves on the left side were slightly atrophic. The patient had had symptoms of cerebellar dysfunction for two years before death. The aneurysm in Hedinger's[15] case occurred in the right vertebral artery and was the size of a hazelnut. The patient had had syphilis for twenty-three years and for the last eight years had presented left hemiplegia. Fourteen days before death violent headache occurred, with associated vomiting, slowing of the pulse and disturbance of consciousness. Rindfleisch[16] recorded the case of a woman aged 51 who had had headache for three years. Six days before death she experienced sudden suboccipital pain and extreme anxiety. She became comatose in three days. Necropsy revealed subarachnoid hemorrhage and a ruptured aneurysm of the right vertebral artery, "the size of a bean." Beadles,[17] in his compilation of 555 cases of intracranial aneurysm, reported only 1 case in which the vertebral artery was involved. He personally observed an aneurysm, the size of a pea, at the junction of the vertebral and the inferior cerebellar artery on the left side, which compressed the medulla and the roots of the seventh, eighth, ninth and twelfth cranial nerves on that side. The patient, an elderly woman, had been admitted to an institution because of dementia of organic origin two and one-half years before her death. She had paralysis of the left side of the face, deafness, weakness of the right arm, which gradually increased, and signs of bulbar palsy. She died a few days after a sudden apoplectic stroke. A large, recent hemorrhage was present in the left cerebral hemisphere. Ruston and Southard[18] reported a case of miliary cerebral and gross bilateral vertebral aneurysms, in which they emphasized suboccipital pain as an important clinical feature. The patient, a woman aged 69, had had episodes of drowsiness for a year. About two weeks prior to her death she experienced an attack

5. Echeverria, M. G.: On Epilepsy, New York, W. Wood & Co., 1870, p. 124.

6. Sevestre: Anévrysme de l'artère vertébrale gauche, Bull. Soc. anat. de Paris **47**:415 (Oct.) 1872.

7. Schultze, F.: Linksseitiger Facialiskrampf in Folge eines Aneurysma der Arteria vertebralis sinistra, Virchows Arch. f. path. Anat. **65**:385 (Dec.) 1875.

8. Osler, W.: Endarteritis and Aneurysmal Dilatation of the Left Vertebral and First Part of the Basilar Arteries, Montreal Gen. Hosp. Rep. **2**:16, 1880.

9. Currier, F. P., and Davis, D. B.: Intracranial Aneurysms, J. Michigan M. Soc. **35**:25 (Jan.) 1936.

10. Weidman, F. D.: Ruptured Aneurysm of the Right Vertebral Artery, J. A. M. A. **65**:1105 (Sept. 25) 1915.

11. Möser, H.: Beitrag zur Diagnostik der Lage und Beschaffenheit von Krankheitsherden der Medulla oblongata, Deutsches Arch. f. klin. Med. **35**:418 (Sept.) 1884.

12. Eppinger, H.: Pathogenesis der Aneurysmen, Arch. f. klin. Chir. **35**:1, 1887.

13. von Hofmann, E.: Ueber Aneurysmen der Basilarterien und deren Ruptur als Ursache des plötzlichen Todes, Wien. klin. Wchnschr. **7**:823 (Nov.) 1894.

14. Ladame, P., and von Monakow, C.: Anévrysme de l'artère vertébrale gauche, Nouv. iconog. de la Salpêtrière **13**:1, 1900.

15. Hedinger, E.: Aneurysma der Arteria vertebralis dextra, Cor.-Bl. f. schweiz. Aerzte **35**:261 (April) 1905.

16. Rindfleisch, W.: Zur Kenntnis der Aneurysmen der basalen Hirnarterien und der bei den intrameningealen Apoplexien auftretenden Veränderungen der Cerebrospinalflüssigkeit, Deutsches Arch. f. klin. Med. **86**:183 (Dec.) 1905-1906.

17. Beadles, C. F.: Aneurisms of the Larger Cerebral Arteries, Brain **30**:285 (Oct.) 1907.

18. Ruston, W. D., and Southard, E. E.: Cerebral Seizures with Suboccipital Pain: Miliary Cerebral and Gross Vertebral Aneurysms, Boston M. & S. J. **154**: 312 (March) 1906.

of sudden, severe, boring pain in the suboccipital region, associated with projectile vomiting. She died suddenly. At necropsy both vertebral arteries were observed to contain fusiform aneurysmal dilatation, 0.75 cm. in diameter, which had not ruptured. Boinet's [19] specimen involved the left vertebral artery, 5 mm. below the basilar artery. The walls of the aneurysmal sac were thickened and hard. Many gummas were present on the surface and in the substance of the brain. There was no clinical history because the patient had been admitted to the hospital in coma. The case reported by Wichern [20] was that of a man who, two months prior to his admission to a hospital, had a stiff neck and headache. He was known to have had syphilis for twenty-four years. He was admitted in coma, with stiffness of the neck and no pupillary reactions. In two days he had return of consciousness. He complained of stiffness of the neck and headache. Lumbar puncture yielded bloody fluid on repeated occasions. About three weeks after admission he had a generalized convulsion and died. Necropsy revealed a ruptured aneurysm, the size of a pea, in the left vertebral artery. In Bailey's case,[21] that of aneurysm of the right vertebral artery, there was a history of weakness of the right arm and stiffness of the neck for two or three years. Four months before the patient's death he began to experience severe, sharp, shooting pains in the back of the neck, which radiated to the top of his head. The paresis of the right upper extremity progressed, and tingling and numbness were felt in the right hand and foot. He became bedfast as a result of flaccid paralysis of all the extremities. The knee jerks were hyperactive. Anesthesia of the body was present up to a line corresponding to the distribution of the second cervical segment. Death resulted from pulmonary edema. At necropsy an extensive aneurysm of the right vertebral artery was discovered. This compressed the spinal cord in its highest portion. The affected artery was the seat of advanced endarteritis.

In Hedinger's [22] case a woman aged 47 had suffered from typical migraine for many years. In 1913 she fell down a series of steps and struck her neck and the back of her shoulders. For one week thereafter she had severe pain in the back of the neck. After the accident she had frequent episodes of pain in the shoulders and neck. Four years later she had sudden, severe pain in the back of her neck, and on the following day she was found dead. Necropsy disclosed an aneurysm of the left vertebral artery, which was 1 cm. long and 0.5 cm. wide, and hemorrhage over the base of the brain.

Cases have been reported with no clinical signs or with scant clinical data. Thus, Kerppola [23] reported that his patient complained of headache, pressure in the head and attacks of vertigo during the last few weeks of life. No clinical signs were mentioned. At necropsy an aneurysm of the right vertebral artery was observed. Morrow [24] described a spontaneously healed fusiform aneurysm of the right vertebral artery, discovered in a body used for dissection in a medical school. No history was available. The medulla was pressed into an unrecognizable mass by the large aneurysm. The walls of the vessels of the circle of Willis showed no table sclerosis. A case with a history of trauma to the head was cited by Wells.[25] At the age of 18 years his patient had a severe injury to the head, followed by unconsciousness, which persisted for three or four days. He began to complain of severe headache when he was about 40 years old and had repeated syncopal attacks three years before his death, at the age of 54. In progression, there developed roaring in his ears, diplopia, pain in the left side of his face and the teeth on that side, unsteadiness and weakness of gait and paresis of his lower limbs. He lost control of the bowel and bladder and displayed a bulbar syndrome, with inability to swallow or articulate properly. Death was due to pneumonia. Necropsy revealed a large, ovoid, unruptured saccular aneurysm of the left vertebral artery, which compressed the adjacent portions of the pons, cerebellum and medulla, as well as the roots of the sixth to the ninth cranial nerve on the same side.

An interesting case was described by Packard and Zabriskie.[26] Two weeks before his death, from apoplexy, a man aged 50 suddenly had fronto-occipital headache and pain in the back and legs and was unable to open the left eye. Examination revealed complete ophthalmoplegia on the left side. The left pupil was fixed; the right pupil responded in accommodation but not to stimulation with light. Studies of the blood and spinal fluid revealed nothing abnormal. The patient died suddenly. Necropsy showed a ruptured aneurysm, measuring 5 cm. in length and 0.75 cm. in diameter. in the left vertebral artery. The authors expressed the belief that leakage from the sac must have occurred at the onset of symptoms. The blood had burrowed forward and had collected in a mass, involving the third, fourth and sixth cranial nerves on the left side.

Conway's [27] case, again, emphasizes the prevalence of occipital or nuchal pain as a prominent symptom. His patient, a woman aged 40 years, two years before admission to the hospital experienced paroxysms of pain over the left side of the lower jaw and the lower left side of the face, the attacks often being associated with dizziness and disturbance of gait. Shortly before her admission to the hospital she had severe pain in the back of the neck. She soon became stuporous. Examination revealed palsy of the right side of the face and paresis of the left extremities, palsy of both external rectus muscles and optic neuritis. She died suddenly. Necropsy revealed evidence of old hemorrhage over the cerebellum and an unruptured aneurysmal dilatation of the left vertebral artery, which had compressed the cerebellum. Atheromas were present to a notable degree in the cerebral vessels.

19. Boinet, E.: Anévrisme syphilitique de l'artère vertébrale gauche, Compt. rend. Soc. de biol. **69**:210, 1910.

20. Wichern, H.: Zur Diagnose perforierender Aneurysmen der Hirnarterien, München. med Wchnschr. **58**:2724 (Dec.) 1911; Deutsche Ztschr. f. Nervenh. **44**:220 (May) 1912.

21. Bailey, P.: Aneurysm of the Vertebral Artery, M. Rec. **83**:266 (Feb.) 1913.

22. Hedinger, E.: Die Bedeutung des indirekten Traumas für die Entstehung der Aneurysmen der basalen Hirnarteries, Cor.-Bl. f. schweiz. Aerzte **47**:1393 (Oct.) 1917.

23. Kerppola, W.: Zur Kenntnis der Aneurysmen an den Basalarterien des Gehirns mit besonderer Berücksichtigung der begleitenden Arteriosklerose in denselben Gefässen, Arb. a. d. path. Inst. d. Univ. Helsingfors **2**:115 (Aug.) 1919.

24. Morrow, J. F.: Aneurysm of Vertebral Arteries, M. Rec. **100**:894 (Nov.) 1921.

25. Wells, H. G.: Intracranial Aneurysm of the Vertebral Artery, Arch. Neurol. & Psychiat. **7**:311 (March) 1922.

26. Packard, M., and Zabriskie, E. G.: Basal Cerebral Hemorages, J.A.M.A. **85**:1633 (Nov. 21) 1925.

27. Conway, J. A.: Two Cases of Cerebral Aneurysm Causing Ocular Symptoms, with Notes of Other Cases, Brit. J. Ophth. **10**: 78 (Feb.) 1926.

The association of convulsions with vertebral aneurysm is illustrated by the case reported by Keegan and Bennett.[28] The condition was of eight years' duration and was characterized by the sudden onset of intense pain in the back of the head, followed quickly by generalized convulsions and unconsciousness, which lasted for several hours. The patient showed signs of meningeal irritation and slight weakness of the right side of the face. Lumbar puncture yielded bloody fluid, under an initial pressure of 14 mm. of mercury. In three weeks the attacks recurred. About seven years later she had weakness in gait, nystagmus and ataxia. Studies of the blood and spinal fluid revealed nothing abnormal. Blood pressure was 210 systolic and 125 diastolic. Over a period of a year her weakness progressed, and she suddenly manifested signs of progressive failure of the medullary centers and died. Necropsy revealed an unruptured, oval aneurysm of the left vertebral artery, 2.5 cm. in diameter, which had notably compressed the adjacent portion of the medulla. There was no subarachnoid hemorrhage. It is obvious that eight years before she had experienced a rupture of this aneurysm, which had healed. The authors included another case of aneurysm, of the vertebral artery in this instance, which had ruptured and produced a massive basilar subarachnoid hemorrhage. The patient had been comatose on admission, and there was no antecedent clinical history.

The etiologic role of trauma in the production of vertebral aneurysm is illustrated by the case of Dial and Maurer.[29] In a number of cases already cited trauma seems to have precipitated acute symptoms of an aneurysm already established, but Dial and Maurer reported the case of a 2 year old child who sustained a fracture of the skull, with unconsciousness, and who, five days after apparent recovery, suddenly became comatose, with rigidity of the neck and signs of failure of medullary function. Death occurred twenty-nine days after the onset of symptoms. Necropsy revealed a small ruptured aneurysm of the right vertebral artery. The authors could not conclude whether the lesion was traumatic or congenital in origin.

Although syphilis is not regarded as a common cause of intracranial aneurysm, it can apparently produce such a lesion. Thus, Maass,[30] in a review of aneurysms of the brain due to syphilis, reported a case of a small aneurysm of this origin at the junction of the vertebral arteries and the basilar artery. He also cited a case of sudden rupture of a small syphilitic aneurysm of the right vertebral artery, without clinical details.

Boyd and Werblow[31] recorded an interesting case of coarctation of the aorta, dissecting aneurysm of the aorta and aneurysm of the left vertebral artery. They noted that since the circulation for the lower half of the body is derived almost entirely from the subclavian arteries in cases of aortic coarctation, it is not surprising that the vertebral artery, representing the first branch of the subclavian artery and participating in the formation of a collateral circulation, should become enlarged and dilated. In the authors' case the aneurysmal dilatation caused partial pressure atrophy of the left cerebellar hemisphere.

Loder's[32] case is a good example of the type of medullocerebellar syndrome which is frequently produced by the chronic, large, unruptured type of aneurysm of the vertebral artery. A man aged 67, fifteen years before admission to the hospital, had a vertiginous, syncopal attack while driving his car. He had minimal palsy of the left side of the face and paresis of the left hand, which cleared in three weeks. One year before his entrance to the hospital he noted paroxysms of sharp, shooting, stabbing pain behind the right ear, which radiated down the neck and was usually precipitated by his bending over and suddenly turning his head, especially to the left. The pain in time became constant. Diminution of hearing, more pronounced on the right, soon developed. He experienced momentary severe vertigo, followed by episodes of unconsciousness. The gait became unsteady, and he tended to stagger to the right. The headaches became more pronounced, the pain radiating to the right temporal and frontal regions, and he began to have difficulty in swallowing solid foods. Examination revealed palsy of the left side of the face, a diminished gag reflex on each side, profound generalized weakness and ataxic gait, with dyssynergia and dysmetria in all limbs, especially those on the right side. In the hospital progressive bulbar palsy developed, with inability to swallow solids and liquids. He died of pneumonia. Necropsy revealed a distinct, ovoid tumor, measuring 2.5 by 2 by 3 cm., emerging from the right vertebral artery. The aneurysmal mass produced a hollow excavation in the adjacent portion of the medulla, which was displaced to the left. The mass also compressed the adjacent basilar portion of the right cerebellar hemisphere. The seventh to the twelfth cranial nerve on the same side showed evidence of compression.

Bassoe[33] reported a case of aneurysm of syphilitic origin. A woman aged 31, known to be infected with syphilis, began to have headaches six months before her admission to the hospital. Immediately before admission the headaches increased; she became delirious and had two convulsions. On her first admission she had pain over the vertex, the occiput and the back of the neck. When she moved her head, the pain extended to the sacrum. The neck was stiff. Lumbar puncture yielded bloody fluid under increased pressure. Studies of the blood and spinal fluid revealed nothing abnormal. The right foot became paralyzed, with atrophy. Within six months she was discharged from the hospital, in good condition. About one year later she was readmitted because of shooting pains in the left leg and dizziness. She had diminution of touch and pain sensation on the right side from the seventh thoracic level to the toes. The spinal fluid was clear. Almost eleven years later she was again admitted with complaints of weakness of the left side of the body and pain about the left ear, which radiated down the body, especially on the left side. There was no definite loss of motor power or sensation. Lumbar puncture yielded a clear fluid, with a cell count of 7 per cubic millimeter, a negative Wassermann reaction, a total protein content of 99.6 mg. and a sugar content of 64 mg. per hundred cubic centimeters. Bronchopneumonia developed and she died. Necropsy showed that the medulla was greatly displaced to the right by a firm, dark red mass,

28. Keegan, J. J., and Bennett, A. E.: Cerebral Aneurysm and Cortical Herniation, Arch. Neurol. & Psychiat. **26**: 36 (July) 1931.

29. Dial, D. L., and Maurer, G. B.: Intracranial Aneurysms, Am. J. Surg. **35**:2 (Jan.) 1937.

30. Maass, U.: Die Syphilis als haüfigste Ursache der Aneurysmen an der Gehirnbasis, Beitr. z. path. Anat. u. z. allg. Path. **98**: 307, 1937.

31. Boyd, L. J., and Werblow, S. C.: Coarctation of the Aorta, Dissecting Aneurysm and Aneurysmal Dilatation of the Left Vertebral Artery, Ann. Int. Med. **11**: 845 (Nov.) 1937.

32. Loder, K. J.: Aneurysm of Vertebral Artery, New York M. Coll. & Flower Hosp. Bull. **1**:62 (June) 1938.

33. Bassoe, P.: Aneurysm of the Vertebral Artery, Arch. Neurol. & Psychiat. **42**: 127 (July) 1939.

3.5 by 3 cm., which proved to be an unruptured aneurysm of the left vertebral artery. In the basilar artery, less than 1 mm. beyond the union of the two vertebral arteries, was a globular aneurysmal dilatation, 12 mm. wide. Within 5 mm. of the upper bifurcation of the basilar artery was a third, yellower, aneurysm, which was 1 cm. long and 4 mm. wide. A fourth, rust-colored, circular nodule was observed inside the bulb. All these aneurysms were unruptured, had thick walls and contained old clots. The subarachnoid hemorrhage, which occurred twenty-three years before, undoubtedly had been caused by rupture, with subsequent healing, of a similar aneurysm. The patient also had syphilitic aortitis and generalized arteriosclerosis. Bassoe also reported a second case of aneurysm occurring in a man 52 years of age. Five years before examination he had experienced several attacks of dizziness and severe headache, usually at night. Two years after the onset of these symptoms he noted numbness of the left side of the body, which persisted, and dragging of one foot. Five days before examination he had a severe vertiginous spell, which was followed by frequent clonic spasms of the extremities on the right side and difficulty in swallowing. He had a generalized convulsion. Examination revealed a Babinski sign bilaterally. The deep tendon reflexes in the lower extremities were increased, more on the left side than the right. Pain and temperature sensations were impaired on the left side of the body, except for the face. There was ataxia of the right hand. The right leg was slightly weak. Speech was thick. Lumbar puncture yielded clear spinal fluid. The Wassermann reaction was negative. The patient's condition improved, and he went to the Johns Hopkins Hospital for further study. Suspecting a tumor of the brain stem, Dr. Dandy explored the posterior fossa and encountered "a vascular aneurysm with a tremendous enlargement of the left vertebral artery." The wound was closed, and it was planned to ligate the vessel and remove the aneurysm later. However, the patient had more convulsions and died.

The cases of Dandy [34] and of Richardson and Hyland [35] illustrate the simulation of a neoplasm of the cerebellopontile angle by an aneurysm of the vertebral artery. The patient of Richardson and Hyland, a man aged 49, for ten years had suffered from a mental syndrome which had been diagnosed as dementia precox, the paranoid type. He had a history of tinnitus in the left ear for two years and frequent occipital headaches. The year prior to examination he had increasing deafness on the left side. For six months he had had numbness of the left side of the face, and for two months, nausea, diplopia, weakness of the left side of the face and unsteadiness of gait. Neurologic examination revealed paresis of the extremities on the left side. Horizontal nystagmus was present on left lateral gaze. There were clinical signs of palsies of the third, fifth, sixth, seventh and eighth cranial nerves on the left side. At operation a nodular tumor was observed in the left cerebellopontile angle, which after a hemorrhage was recognized as an aneurysm. The patient had a high postoperative fever, lapsed into coma and died. At necropsy a large, dumbbell-shaped, nodular aneurysm, measuring 5 by 3 by 2 cm., was seen on the anterolateral aspect of the left side of the pons; this mass filled the cerebellopontile angle and was firmly compressed against the sphenoid bone. The aneurysm was attached by a narrow neck to the trunk of the right vertebral artery at its junction with the basilar artery. The left vertebral artery was small and threadlike. Dandy's [34] patient, a woman aged 63, presented the initial symptoms of progressive deafness and roaring in the left ear. One year after the onset of symptoms she had attacks of extreme vertigo, especially on quick change of posture, associated with nausea and vomiting. The deafness in her left ear increased, as did the roaring, and unsteadiness of gait developed. Operation revealed an aneurysm under the left eighth cranial nerve, which was stretched over the aneurysmal mass. The aneurysm was traced downward and observed to be continuous with the left vertebral artery.

Globus and Schwab [36] reported a case which also offered signs and symptoms suggestive of a midline tumor of the posterior fossa. In a woman aged 50 severe pain had developed on the left side of the neck eight years before. Dizziness occurred in an episodic fashion, associated with headache over the right supraorbital region. Just before her admission she had difficulty in swallowing and articulation, with generalized weakness. Examination showed bilateral papilledema and postneuritic atrophy, horizontal nystagmus in both lateral planes, deviation of the jaw to the left, paresis of the left extremities and a broad-based gait. The spinal fluid was clear and colorless, and the total protein content was 64 mg. per hundred cubic centimeters. Laryngoscopic examination disclosed palatal paralysis. Roentgenologic examination of the skull revealed nothing abnormal. Caloric tests suggested a lesion of the posterior fossa. A ventriculogram revealed considerable dilatation of both lateral ventricles, the right being slightly larger than the left; the third ventricle and the iter were visualized. Suboccipital exploration was considered, but the patient died suddenly. Necropsy revealed a large, bluish mass which compressed the inferior surface of the left cerebellar hemisphere, the upper half of the medulla and the pons. It seemed to extend into the foramen magnum. The mass was observed to be an aneurysm of the left vertebral artery, which measured 1.5 by 1 by 0.75 inch (3.8 by 2.5 by 1.9 cm.) and which, on subsequent study, proved to be due to proliferative endarteritis.

COMMENT

Of the 72 cases of aneurysm of the vertebral artery found in the literature, 35 were reported with sufficient historical and clinical data to make possible an analysis of the clinical features.

The age of onset of aneurysms of the vertebral artery varied from 2 to 69 years, but the majority of cases were observed in patients from 40 to 60 years of age. Of the 35 cases analyzed, 25 occurred in this age period. In 22 of the 35 cases with data concerning sex the patients were males and in 13 they were females.

The causes of intracranial aneurysm are generally given as congenital defect in the vascular walls, arteriosclerosis, syphilis, trauma and septic embolism. Arteriosclerosis undoubtedly is the chief cause in most instances, particularly in cases occurring in the older age groups. It was the most prevalent condition in this series of cases. There is some difference of opinion as to the frequency of syphilis as an etiologic factor.

34. Dandy, W. E.: Pathologic Changes in Ménière's Disease, J.A.M.A. **108**: 931 (March 20) 1937.

35. Richardson, J. C., and Hyland, H. H.: Intracranial Aneurysms, Medicine **20**: 1 (Feb.) 1941.

36. Globus, J. H., and Schwab, J. M.: Intracranial Aneurysms, J. Mt. Sinai Hosp. **8**: 547 (Jan.-Feb.) 1942.

In 5 reported cases of aneurysm of the vertebral artery the lesion was ascribed to syphilitic disease of the arteries. In 1 of these cases, described by Boinet,[19] an aneurysm of the left vertebral artery was associated with gummas of the brain and meninges. Hedinger [15] described a case of an unruptured aneurysm of the right vertebral artery in a syphilitic patient who had been hemiplegic for eight years. The aneurysmal sac revealed histologic evidence of syphilitic aortitis. Maass [30] described 2 cases of a small ruptured aneurysm of the vertebral artery in which death occurred during initial subarachnoid hemorrhage. The histologic evidence of syphilis in these cases is debatable. Bassoe [33] reported a case of saccular aneurysm of the left vertebral artery compressing the adjacent portion of the pons and medulla, with histologic evidence of syphilitic arteritis.

The part played in the formation and rupture of these aneurysms by congenital anomalies of vessels, congenital aneurysm, trauma, hypertensive disease and arteritis following embolism is difficult to evaluate from the cases reported.

Trauma as a cause cannot be established conclusively in this series of cases. Instances of aneurysm of the vertebral artery after fracture of the skull or injury to the head have been reported. Hedinger [22] recorded the case of a man who died suddenly of subarachnoid hemorrhage four years after a severe fall. The patient had experienced recurrent pain in the neck after the accident. Necropsy revealed a small ruptured aneurysm of the left vertebral artery. Dial and Maurer [29] recorded the case of a 2 year old child who died of sudden subarachnoid hemorrhage shortly after sustaining a fracture of the skull. A small ruptured aneurysm of the right vertebral artery was observed. However, the authors could not establish to their satisfaction whether the aneurysm was traumatic in origin or was due to a congenital defect. In the case reported by Morrow [24] and in that described in this paper there were histories of antecedent cranial trauma.

Clinical Features.—It is possible to classify aneurysms of the vertebral artery under two types, acute and chronic. In cases of both types death occurred frequently from rupture and subarachnoid hemorrhage. The number of deaths from this cause in the cases collected was 16.

Under the acute type may be placed the cases characterized by sudden death due to hemorrhage with no preliminary symptoms. These cases constitute a small group. Cases of the chronic type form a much larger group; they are characterized by a prolonged history, often with focal neurologic symptoms. The aneurysms in this category are of the large, unruptured type which persist for months or years and which rarely rupture to cause sudden death. Twenty-one of the cases studied fell in this group.

The nature of the symptoms produced by an unruptured aneurysmal mass of the vertebral artery depends on its location and size, its rate of expansion, the secondary changes which it may undergo and the pressure produced on the structures of the posterior fossa. It is easy to understand the variability of the symptoms and signs when one studies the course of the vertebral artery, coming into contact, as it does, first with the upper cervical portion of the cord, as it proceeds upward to enter the cranial cavity by way of the foramen magnum, and then with the side of the medulla and the basilar surface of the cerebellar hemisphere, and finally inclining toward the ventromedian line and, at the posterior border of the pons, joining its fellow artery to form the basilar artery.

The most frequent and striking symptom is suboccipital headache and nuchal pain, characterized by its episodic nature in most cases, although it may be persistent. The pain in the neck often radiates and is aggravated or precipitated by change in position of the head and neck. In many cases it is associated with generalized headache. This symptom was recorded in 15 cases of our series. It is not specific for aneurysm of the vertebral artery, but it is characteristic of an extramedullary expanding lesion of the high cervical region of the cord or the foramen magnum and of tumor of the posterior fossa.

Vertigo associated with nausea and vomiting occurs in most cases. Paralysis of the fifth to the twelfth cranial nerve is frequently encountered. Tinnitus and deafness occurred in 4 of the collected cases. Other early symptoms recorded were irritability, prolonged drowsiness, periodic headache, vague cerebellar and vestibular symptoms and symptoms suggesting increased intracranial pressure which defied localization. Papilledema was recorded in only 2 of the collected cases (Rindfleisch [16] and Globus and Schwab [36]).

Morrow [24] emphasized that aneurysms of the vertebral artery do not tend to rupture early. This fact probably accounts for the greater frequency of cases of the chronic type the symptoms of which suggest psychogenic disease. Most frequently the condition terminates in a complex suggesting slow medullary compression. The symptoms may exist for two months (Wichern [20]) or for more than a decade (Bassoe [33]), and the course of the illness tends frequently to be punctuated by acute episodes which leave few residual effects, as illustrated by the cases of Wells,[25] Keegan and Bennett,[28] Loder [32]

and Bassoe.[33] Eventually a well developed picture of medullary compression or sudden subarachnoid hemorrhage terminates the clinical course. Oppenheim [37] emphasized that the development of the disease is generally protracted and that the bulbar symptom complex does not as a rule come on suddenly, but is steplike in onset, sometimes becoming suddenly acute. Seizures appear repeatedly during the illness, characterized by nuchal rigidity, incoherent speech, paralysis of deglutition, dyspnea, changes in the pulse and, occasionally, mental confusion. The bulbar symptoms gradually subside, to recur with a new attack. In the intervals phenomena remain which are due to the irritation or the paralytic condition of one or of several bulbar nerves or to the effects of compression on the adjacent portion of the medulla, cerebellum or pons.

Unfortunately, in few cases have observations on the spinal fluid been recorded. In each instance in which it was noted the total protein content of the spinal fluid was elevated, the level ranging from 64 to 116 mg. per hundred cubic centimeters. In instances in which the aneurysm has not ruptured, the spinal fluid may be clear or xanthochromic. Other laboratory studies offer no clue as to the possible origin of the lesion. Ventriculograms reveal considerable dilatation of the ventricular system, such as is seen with any lesion in the posterior fossa which encroaches on the fourth ventricle.

A bruit was detected in only 1 case. Möser [11] heard a bruit on each side between the mastoid process and the vertebral column. Necropsy showed the aneurysm in the posterior fossa near the foramen magnum, in association with the left vertebral artery.

In the majority of cases the clinical picture may lead one to suspect a tumor of the brain or the high cervical portion of the spinal cord. In 10 of the collected cases the final clinical syndrome was that of a neoplasm of the posterior fossa. In 2 of the reported cases a typical history and signs of a neoplasm of the cerebellopontile angle neoplasm were presented (Richardson and Hyland,[35] Dandy [34]). The unruptured aneurysm may simulate an extramedullary neoplasm in the high cervical portion of the cord with extension through the foramen magnum. The cases reported by Bailey [21] and Barraud [38] are illustrative of this condition.

The clinical symptoms of vertebral aneurysm are not diagnostic before rupture. In cases of this type the clinical signs are due mainly to the pressure exerted on neighboring structures by the enlarging aneurysmal sac. Signs resulting from actual spontaneous subarachnoid hemorrhage in cases of aneurysm of this type are slight and are often absent during the clinical course. The patient frequently complains of pain in the back of the neck, which may radiate and which is made worse by movements of the head and neck. Compression of the cerebellum and medulla evokes the symptoms of incoordination and bulbar paralysis, which develop by easy stages or in a subacute manner. In addition, symptoms of irritation and paralysis of the basilar nerves appear. The fifth to the twelfth cranial nerve are most often involved. The spinal fluid may be clear or xanthochromic. The protein content of the spinal fluid is always elevated. The spinal fluid pressure may or may not be elevated. The syndrome envoked may simulate that of neoplasm of the posterior fossa, the region of the foramen magnum or the high cervical portion of the cord.

The exact diagnosis of an unruptured aneurysm of the vertebral artery during life is no more possible today than it was when Gull [39] stated, nearly eighty-five years ago that "although we may from the circumstances sometimes suspect the presence of aneurysm within the cranium, we have at least no symptoms upon which to ground more than a possible diagnosis."

SUMMARY

Large intracranial aneurysms of the vertebral artery are rare.

A clinical picture dominated by intermittent and long-standing symptoms of vague cerebellomedullary or pontile involvement and gradual compression of the medulla should suggest the possibility of aneurysmal dilatation of the vertebral arteries. This diagnostic consideration is especially pertinent in the presence of suboccipital headache and nuchal pain which may be aggravated by change in the position of the head.

The clinical picture may lead to a suspicion of tumor of the posterior fossa (cerebellomedullary or cerebellopontile), tumor in the region of the foramen magnum or neoplasm of the high cervical portion of the cord.

In cases of unruptured aneurysm there appears to be no specific sign or symptom which allows a preoperative differentiation between aneurysm of the vertebral artery and tumor.

Jefferson Medical College of Philadelphia.

37. Oppenheim, H.: Disease of the Nervous System, translated by E. E. Mayer, ed. 2, Philadelphia, J. B. Lippincott Co., 1904.

38. Barraud, A.: Sur un cas d'anévrisme de l'artère vertébrale gauche dans son pacours intrarachidien, Rev. de laryng. **57**:375 (March) 1936.

39. Gull, W.: Aneurism of the Cerebral Vessels, Guy's Hosp. Rep. **5**: 281, 1859.

ABSCESS OF THE MEDULLA OBLONGATA

REPORT OF A CASE

GEORGE D. WEICKHARDT, M.D., AND JAMES W. WATTS, M.D.
WASHINGTON, D. C.

Localization of an abscess in the medulla oblongata is rare. A rather complete survey of the literature shows that only 9 cases have previously been reported (table). Another case is here added to the list.

REPORT OF CASE

White man aged 34. History of intermittent discharge from right ear since childhood. Mastoiditis and facial paralysis (right side), relieved by simple mastoidectomy; followed by recurrent paroxysms of meningitis. Persistence of symptoms, necessitating radical mastoidectomy. Signs of petrositis and dysfunction of ipsilateral cerebellar hemisphere. No cerebellar lesion disclosed by exploratory craniotomy. Focal meningitic complications and intramedullary abscess revealed at necropsy.

Anamnesis.—The patient first applied for treatment on Sept. 16, 1942 because of pain in the right ear. He told us that the ear had been draining intermittently since early childhood. He recalled having a fracture of the skull at the age of 10 years, but apparently there were no serious sequelae.

Physical Examination.—The patient appeared well nourished and healthy and did not seem acutely ill. The right eye was amblyopic. There was pronounced internal strabismus. The pupillary reactions were normal. There was no ptosis or nystagmus. The drum membrane of the right ear showed a plug of white debris over the area of the lateral process of the malleus. When this was removed, a thick, purulent secretion oozed out. Hearing was lost in this ear. There was no tenderness over the mastoid. The left ear was normal. The heart was normal, and the lungs were clear except for a few asthmatic wheezes. The deep tendon reflexes were equal and lively on the two sides. No meningitic phenomena were recognized.

Serologic tests of the blood for syphilis gave negative results. Roentgenographic examination showed that the cells of the right mastoid were completely obliterated.

Clinical Course.—Intensive treatment with sulfonamide compounds produced no clinical improvement. On October 19 severe pain developed around the right ear, radiating to the forehead. Mastoidectomy was advised, but permission for operation was refused. On November 14 paralysis of the right side of the face developed. A simple mastoidectomy was immediately performed on the right side, and pus under pressure was released.

Data on Cases of Abscess of the Medulla Reported in the Literature *

Author	Age, Yr.	Sex	Site of Primary Infection	Position and Extent of Abscess	Motor Phenomena	Sensory Phenomena	Cranial Nerve Signs	Approximate Duration of Life Following Involvement of Central Nervous System
Abercrombie [8]	1½	M	Unknown	Medulla (central)	Hemiparesis (R)	None	None	3 mo.
Forget [4]	44	F	Unknown	Medulla; pons (R)	Convulsive movements of face (R)	None	VII (R)	5 days
Bircher [2]	44	M	Right forearm	Medulla; pons (R)	Hemiparesis (L)	Hemianalgesia (L)	V (R) VII (R) XII (R)	5 days
Eisenlohr [1]	43	M	Left lung	Medulla; C 1 C 2 (L)	Quadriplegia (L > R)	Hemianesthesia (L)	None	4 days
Schlesinger [6]	31	M	Prostate	Medulla (central)	Paraplegia (R > L)	Hyperesthesia of trunk	None	7 weeks
Dogliotti [3]	16	M	Thumb	Medulla; C 1 (R)	Quadriplegia	Hemianesthesia (L)	VII (R) XII (R)	24 days
Cassirer [5]	39	M	Appendix	Medulla; pons (R)	None	Hemianesthesia (L)	V (R) VI (R) VII (R)	8 days
Moniz [9]	Adult	M	Ear (?)	Medulla (R)	None	None	V (R) VII (R)	6 mo.
Norman [7]	43	M	Lungs	Medulla (central)	None	Hypesthesia of right arm	V (R) XII (L)	10 days
Weickhardt and Watts	34	M	Ear	Medulla; flocculus; pons	None	Impaired position sense (R)	V (R) VI (R) VII (R) VIII (R) IX (R) XII (R)	9 days

* The right side is indicated by R and the left side by L.

The postoperative course was uneventful for twenty-one days. On December 4 the patient began to complain of severe headache. The neck was somewhat rigid; Kernig's sign was elicited, and the temperature rose to 101.4 F. The facial paralysis had practically disappeared. The operative incision was nearly healed, but pus continued to drain from the auditory meatus. Examination of the spinal fluid showed 3,500 leukocytes per cubic millimeter (50 per cent lymphocytes and 50 per cent neutrophils), increased protein and no sugar. No organisms could be seen in the smear, and culture of the fluid was sterile. Treatment with sulfadiazine for a week led to complete disappearance of meningitic signs.

On Jan. 9, 1943 a second episode of meningeal irritation occurred. The mastoid incision at this time was well healed. The aural discharge persisted, although drainage seemed inadequate. Another spinal puncture yielded fluid the composition of which was essentially similar to that of the first specimen (2,000 cells per cubic millimeter, of which 75 per cent were neutrophils and 25 per cent lymphocytes; increased protein; 24 mg. of sugar per hundred cubic centimeters; a negative Kolmer reaction, and a colloidal gold curve of 000112222). A smear and culture again showed no organisms. For a second time the signs of meningitis responded to sulfadiazine therapy.

The patient was comfortable until January 31, when an abscess appeared in the mastoid scar. The ear continued to drain freely. A radical mastoidectomy was carried out on February 10. The postoperative course was satisfactory for twenty-four days. On March 6 signs of meningitis appeared for a third time, together with weakness of the right side of the face. Aural discharge continued undiminished. Repeated spinal punctures failed to reveal a causative organism. Within a few days the patient began to complain of distressing dizziness. The facial paralysis became complete. On March 10 the patient showed a strong tendency to fall to the right on attempting to stand. There was horizontal nystagmus on his gazing far to the right or to the left. Speech showed a gradually increasing bulbar quality. On March 12 he showed complete anesthesia over the distribution of the right trigeminal nerve, with absence of the corneal reflex. The right abducens nerve was paralyzed. The right arm and leg showed slowly increasing ataxia. The speech difficulty became more pronounced. The following day the right half of the palate was paralyzed, and there was pronounced dysphagia. The protruded tongue deviated to the right. At this stage our diagnosis was osteomyelitis of the right petrous bone and diffuse purulent leptomeningitis. Abscess of the right cerebellar hemisphere was suspected.

On March 18 the cerebellar hemisphere was explored with the brain cannula. No abscess was encountered.

The patient's condition following the operation continued practically unchanged until 9 o'clock the following morning, when it was noted that respirations were rather shallow. An hour later he died suddenly and quite unexpectedly.

Necropsy.—A complete autopsy revealed that the internal organs were essentially normal. The brain showed no signs of increased intracranial pressure. The anterior surface of the right lobe of the cerebellum was densely adherent to the petrous pyramid. The dura here was thickened and granular. An attempt to sever the adhesions led to the discovery of an abscess cavity in the region of the cerebellopontile angle. This cavity contained several cubic centimeters of greenish yellow pus. The abscess extended into the substance of the brain stem, involving principally the right dorsolateral portion of the medulla oblongata and the right flocculus. It also extended upward into the lower portion of the pons. No other focal lesion was observed in the brain. The petrous portion of the right temporal bone was soft and necrotic. In its substance were two irregular sequestrums. Necrosis extended for a short distance into the squama. The anatomic diagnosis was osteomyelitis of the right temporal bone and abscess of the brain stem.

Cross section through the medulla oblongata, showing abscess in the right dorsolateral portion. Weigert preparation.

Unfortunately, no bacteriologic examination was made.

Histopathologic Study (Dr. Walter Freeman).—A cross section through the medulla oblongata (figure) showed that the abscess occupied its extreme lateral portion and compressed medially such structures as the fasciculus solitarius, the descending root of the trigeminal nerve and the inferior olivary body. The corpus restiforme at this level was almost completely destroyed. The abscess was not clearly walled off. There was obvious extension into the surrounding tissues, as evidenced by collections of leukocytes around blood vessels at some distance from the abscess cavity. The Laidlaw stain showed moderate proliferation of connective tissue surrounding the abscess cavity, but nowhere did it approach the formation of an actual wall. The Bodian stain showed that the axis-cylinders in the immediate

vicinity of the abscess were swollen to large proportions and tended to undergo liquefaction.

Microscopic examination of the petrous pyramid showed small portions of necrotic bone in a matrix of granulation tissue heavily infiltrated with leukocytes.

COMMENT

Abscesses of the medulla oblongata reported in the literature present a remarkably heterogeneous clinical picture. They are alike only in being invariably fatal. Slight variations in position and size of medullary lesions produce remarkably different syndromes. Abscesses in the brain stem, furthermore, show a tendency to form elongated cavities, so that several levels, or segments, are likely to be involved. Thus, of the 10 cases encountered, the abscess was limited to the medulla oblongata in only 3. In the cases of Eisenlohr [1] and Dogliotti [2] the lesion could be followed into the upper cervical segments of the spinal cord, while in the cases reported by Bircher,[3] Forget [4] and Cassirer [5] and in our case it extended upward into the pons. In Schlesinger's [6] case there were two abscesses: an elongated lesion involving the cervical and upper dorsal segments of the spinal cord and a pea-sized intramedullary abscess at the level of the pyramidal decussation. There may be other intracranial complications (as in our case).

In 6 of the cases reviewed the abscess was of metastatic origin, with distribution of primary foci as follows: abscess of the forearm [3]; abscess of the lung [1]; abscess of the prostate, leading to purulent meningitis [6]; paronychia of the thumb [2]; perityphlitis, with abscesses in the liver and lungs,[5] and apical pulmonary tuberculosis, with secondary infection.[7] The lesion in the medulla oblongata of a child described by Abercrombie [8] as an abscess has been regarded by most reviewers as a tuberculoma. Forget's [4] report contains no discussion of pathogenesis. In the case of Moniz,[9] as in our own, invasion of the brain stem was apparently due to direct extension of purulent otitis.

Death is due usually to compression of the medullary centers. In the majority of cases only a few days intervened between onset of neurologic complications and fatal termination. A much longer time elapsed in the cases of Abercrombie, Schlesinger and Moniz.

In our case the infection evidently extended along the petrous portion of the temporal bone and through the dura into the region of the cerebellopontile angle. The first clinical sign to indicate intramedullary abscess formation was the appearance, nine days before death, of hemiataxia. This was evidently due to destruction of pathways in the inferior cerebellar peduncle. The bulbar signs which followed were attributed at the time to the pressure of an expanding cerebellar lesion rather than to invasion of the medulla. The fifth and sixth nerves were evidently involved in the petrosal osteomyelitis. It is felt that the patient had no chance for recovery even if it had been possible to drain his abscess.

SUMMARY

A case of abscess of the medulla oblongata reported here is unique in that origin from infection of the middle ear is clearly demonstrated.

638 Eighth Street N. E.

1028 Connecticut Avenue N. W.

1. Eisenlohr, C.: Ueber Abscesse in der Medulla oblongata, Deutsche med. Wchnschr. **18**:111 (Feb. 11) 1892.

2. Dogliotti, A.: Ascesso del midollo allungato da stafilococchi, Gazz. med. di Torino **50**:841 (Oct. 26) 1899.

3. Bircher, H.: Beobachtungen zur Pathologie des Gehirns: Abscess in Medulla oblongata und Pons, Cor.-Bl. f. schweiz. Aerzte **11**:102 (Feb. 15) 1881.

4. Forget, C.: Note sur les rapports des symptomes avec les lésions encéphaliques, Union méd. **4**:366 (July 27) 1850.

5. Cassirer, R.: Ueber metastatische Abscesse im Centralnervensystem. Isolierter metastatischer Abscess im Pons und in der Medulla oblongata, Arch. f. Psychiat. **36**:153 (Aug.) 1902.

6. Schlesinger, H.: Ueber Rückenmarksabscess, Arb. a. d. Inst. f. Anat. u. Physiol. d. Centralnervensyst. a. d. Wien. Univ. **2**:114, 1894.

7. Norman, H. B.: Abscess of the Medulla Oblongata Associated with Chronic Pulmonary Tuberculosis, Brit. M. J. **1**:403 (March 15) 1941.

8. Abercrombie, J.: Pathological and Practical Researches on Diseases of the Brain and Spinal Cord, ed. 3, Edinburgh, Maclachlan, Stewart & Co., 1836, p. 103.

9. Moniz, E.: Abcès isolé du bulbe, Rev. d'oto-neuro-opht. **12**:568 (Oct.) 1934.

Abstracts from Current Literature

EDITED BY DR. BERNARD J. ALPERS

Physiology and Biochemistry

THE EFFECT OF ELECTRICALLY AND CHEMICALLY INDUCED CONVULSIONS ON CONDITIONED REFLEXES. M. KESSLER and E. GELLHORN, Am. J. Psychiat. **99**: 687 (March) 1943.

Kessler and Gellhorn produced a conditioned response to the sound of a bell in 18 rats and then inhibited the response by failing to reenforce it with the unconditioned stimulus (electric shock). The induction of convulsions by either metrazol or electric shock restored temporarily the inhibited conditioned response.

FORSTER, Philadelphia.

THE PAIN THRESHOLD IN MAN. JAMES D. HARDY, HAROLD G. WOLFF and HELEN GOODELL, Am. J. Psychiat. **99**: 744 (March) 1943.

Hardy, Wolff and Goodell devised an apparatus for the graduated production of thermal pain and studied the variations in the pain threshold. The threshold thus measured was found to be relatively constant in the same subject and to be independent of age, sex, emotional state and fatigue. Despite the constancy of the pain threshold, the authors found that the "alarm" reaction threshold varied widely in the same subject over a period of two months. The pain threshold was dependent only on the strength of the stimulus, and not on the area involved. The effects of lesions of the peripheral and the central nervous system were studied, the authors concluding that lowered pain threshold is never due to structural disease. Structural disease of the nervous system, if it causes any alteration, always raises the threshold.

FORSTER, Philadelphia.

THE EQUILIBRIUM BETWEEN CALCIUM AND CEPHALIN IN VARIOUS SYSTEMS. N. DRINKER and H. H. ZINSSER, J. Biol. Chem. **148**: 187, 1943.

As cephalin can be shown to bind appreciable amounts of calcium, both alone and in the presence of protein, evaluation of the cephalin content of normal and pathologic serums may serve to clarify the role of plasma proteins in the regulation of calcium ion concentration. In the concentrations present in normal plasma, it would seem that 30 to 40 per cent of the bound calcium may be held in nondiffusible form by cephalin.

PAGE, Indianapolis.

OBSERVATIONS ON THE FUNCTIONAL DEVELOPMENT OF THE FOETAL BRAIN. JOSEPH BARCROFT and DONALD H. BARRON, J. Comp. Neurol. **77**: 431 (Oct.) 1942.

Barcroft and Barron studied the normal behavior of 200 sheep fetuses ranging in age from 32 to 147 days with special reference to respiratory movements and to righting and postural movements. Movements of the diaphragm and intercostal muscles were first observed in a fetus 38 days old. The respiratory movements pass through four phases of development: (1) a phase in which the diaphragm contracts with the muscles of the neck, and only with them; (2) a phase in which contractions of the diaphragm are dependent on muscular activity but are not linked to the activity of any specific group of muscles; (3) a phase in which the respirations outlast the stimulus or body activity, and (4) a phase of inhibition. Righting and postural efforts develop in the following order: tonic neck reflexes on the legs; head righting; compensatory movements of the eyes, and body righting. A study of these features was made in fetuses with lesions in the brain stem ranging from the upper cervical portion of the cord to the cerebral cortex. The operations were performed on fetuses between 40 and 70 days of age, and the postoperative study was made on fetuses between 54 and 132 days of age. The region of the brain responsible for the first two phases of respiration is in the lower portion of the medulla, that for the third phase in the pons and that for the fourth phase in the caudal half of the midbrain. The region responsible for the tonic neck reflexes on the legs is the upper cervical portion of the cord and the lower part of the medulla, and that for head righting is in the pons and the lower part of the midbrain. Compensatory movements of the eyes and body righting occur only if the brain stem behind the diencephalon and spinal cord are intact.

ADDISON, Philadelphia.

PERIODICITY IN THE DEVELOPMENT OF THE THRESHOLD OF TACTILE STIMULATION IN AMBLYSTOMA. C. E. COGHILL and R. W. WATKINS, J. Comp. Neurol. **78**:91 (April) 1943.

Coghill and Watkins report the results of tactile stimulation of embryos selected from the same clutch, and therefore of approximately the same age. The embryos were stimulated by the touch of a hair. The point touched and the degree of the touch were controlled under a stereobinocular microscope, mounted so that it could be moved from one dish to another without disturbing the specimens. By this method continuous observation of developing larvae of Amblystoma from first motility to full-swimming stages was possible. There was a pronounced periodicity in the development of sensitivity to light touch until the minimum threshold was reached. This periodicity involved the receptors and was of endogenous origin. It was not attributable to fatigue.

ADDISON, Philadelphia.

HOMOLATERAL REFLEX EXAGGERATION AFTER BRAIN-STEM LESION. FRED A. METTLER and FREDERICK T. ZIMMERMAN, J. Comp. Neurol. **78**: 113 (April) 1943.

Lesions were placed in the brain stem of 6 cats in regions not part of the corticospinal system, as well as in different parts of the corticospinal tract. In 2 cats the lesion extended from the rostral part of the medial geniculate body to the level of the superior olive; in 1 cat the brachium conjunctivum was destroyed, and in 3 cats the brachium pontis was severed. Exaggeration of the knee jerk was not related to damage of the pyramid, substantia nigra, brachium pontis or brachium conjunctivum. Lesions of the tegmentum evoked inequality of the knee jerk. If the lesion was below the level of the red nucleus, the more active reflex was homolateral; if it was rostral to the red nucleus, the more pronounced reflex was contralateral. Such lesions appear to interfere with extrapyramidal mechanisms in the telencephalon.

ADDISON, Philadelphia.

INNERVATION AND "TONUS" OF STRIATED MUSCLE IN MAN. EDMUND JACOBSON, J. Nerv. & Ment. Dis. **97**: 197 (Feb.) 1943.

Jacobson challenges the contention of Hoefer that the latter has measured slight states of muscular contraction in man for the first time and believes that certain of the records on which Hoefer based his conclusions were wrongly interpreted. The failure of Hoefer to record action potentials from leg muscles during standing is attributed to lack of delicacy of the recording system employed, which had a sensitivity of 3 mm. per hundred microvolts. Using his own, more sensitive, instruments, Jacobson found action potentials recorded from the leg muscles of 10 standing subjects. He states, also in opposition to Hoefer, that the string galvanometer records fully as sensitively as the cathode ray oscillograph and that it can be employed to record "brief single motor unit discharges." Although it may be true that normal muscle at rest receives no nerve impulses, Hoefer could not so conclude from his recordings because of their insufficient sensitivity.

CHODOFF. Langley Field, Va.

INVESTIGATION OF EPILEPTIFORM ATTACKS PRODUCED BY SUDDEN COOLING OF FROG SPINAL CORD. M. OZORIO DE ALMEIDA, J. Neurophysiol. **6**: 73 (March) 1943.

De Almeida found that sudden chilling to below 0 C. of the isolated spinal cords of North American frogs failed to produce epileptiform attacks. This was contradictory to the results obtained with South American frogs. In North American frogs attacks could be induced by cooling the cord to below 0 C. with agents such as ethyl chloride or solid carbon dioxide. Preliminary warming of the cord or injection of caffein facilitated the induction of seizures. Direct application of a concentrated solution of sodium chloride produced seizures in both North American and Brazilian frogs. De Almeida compared the effect of chilling the spinal cord in Rana catesbyana, a North American species, both in frogs adapted to North American temperatures and in those of the same species adapted to Cuban temperature for twenty years. In the latter group seizures could be induced. He concludes that the convulsive reaction of the nervous system changes slowly and progressively under the action of temperature.

FORSTER, Philadelphia.

EFFECT OF HYPOTHALAMIC LESIONS ON ELECTRICAL ACTIVITY OF CEREBRAL CORTEX. S. OBRADOR, J. Neurophysiol. **6**:81 (March) 1943.

Obrador studied the effect in 20 cats of lesions of the hypothalamus on the spontaneous electrical activity of the cortex. Lesions of the hypothalamic and basal portions of the brain produced complete abolition of the electrical activity. Lesions of the thalamus produced a similar response. On the basis of these studies and the anatomic evidence available, Obrador

concludes that the hypothalamus may influence the cerebral cortex through its thalamic connections. Complete section of the midbrain failed to alter significantly the electrical activity of the cortex.

FORSTER, Philadelphia.

SPECIFIC EXCITABILITY OF THE ENDPLATE REGION IN NORMAL AND DENERVATED MUSCLE. STEPHEN W. KUFFLER, J. Neurophysiol. **6**:99 (March) 1943.

Kuffler studied the properties of the end plate and the end plate-free region in single nerve-muscle preparations of the adductor longus of the Australian frog. Acetylcholine, nicotine and caffeine depolarized the muscle membrane at the end plate region and so induced impulses. They did not depolarize end plate-free portions of the muscle or set up impulses there. Potassium initiated impulses only in the end plate region, but no difference could be detected in its depolarizing effect at or off the end plate. Curarine opposed the depolarization and excitation caused by all the drugs with the exception of potassium. In chronically denervated muscles the sensitivity of the end plates to acetylcholine, nicotine and caffeine was increased. In these preparations, also, depolarization was limited to the end plate region.

FORSTER, Philadelphia.

FUNCTIONAL ORGANIZATION OF TEMPORAL LOBE OF MONKEY (MACACA MULATTA) AND CHIMPANZEE (PAN SATYRUS). PERCIVAL BAILEY, GERHARDT VON BONIN, HUGH W. GAROL and WARREN S. MCCULLOCH, J. Neurophysiol. **6**:121 (March) 1943.

Bailey, von Bonin, Garol and McCulloch studied the functional organization of the temporal lobe in the monkey and in the chimpanzee by observing the changes in electrical activity produced by various stimuli. They found that the functional organization was the same in the two species. In both species the lobe was divisible into an acoustic and a temporal sector. The acoustic sector was composed of areas 41, 42 and 22. Stimulation of each of these areas caused spikes to appear in each of the others. The temporal sector was composed of areas 21, 20 and 38, each of which "fired" only locally on strychninization. In the macaque a temporopolar area was demonstrated. Commissural connections between the two temporal sectors are restricted to area 21 and probably occur through the anterior commissure.

FORSTER, Philadelphia.

LONG ASSOCIATION FIBERS IN CEREBRAL HEMISPHERES OF MONKEY AND CHIMPANZEE. PERCIVAL BAILEY, GERHARDT VON BONIN, HUGH W. GAROL and WARREN S. MCCULLOCH, J. Neurophysiol. **6**:129 (March) 1943.

Bailey, von Bonin, Garol and McCulloch employed the method of physiologic neuronography in determining the long association fibers in the cerebral hemispheres of the monkey and the chimpanzee. Application of strychnine to area 8 (Brodmann) produced spiking in both ipsilateral and contralateral area 18. Strychninization of ipsilateral area 18 also produced spikes in contralateral area 18. The relayed spike was retarded. Strychninization of area 18 also produced spiking in area 20. Strychninization of area orbitalis agranularis (area 47 of Brodmann, FFA of von Economo) produced well defined strychnine spikes in the anterior portion of the temporal lobe. In none of these pathways could strychnine spikes be sent in the reverse direction.

FORSTER, Philadelphia.

Diseases of the Spinal Cord

A CASE OF EPIDERMOID TUMOR OF THE SPINAL CORD. ROBERT L. CRAIG, Surgery **13**:354, 1943.

Craig's revision of the list of cases of dermoid and epidermoid tumors of the vertebral canal which Boldrey and Elvidge collected from the literature, together with his own report of a case gives a total of 43 cases of such tumors. Craig's case was that of a subpial epidermoid in the lumbosacral portion of the cord associated with spina bifida of the first sacral segment. He explains a sensory level extending to the eleventh thoracic dermatome by the presence of associated arachnoiditis, observed at operation. The poor results obtained on attempted removal of tumors of this type from an intramedullary location are believed to occur because of innumerable folds into which the basement membrane of the tumor is thrown and the consequent enmeshing of the parenchyma.

The series as finally revised contains 20 probable cases of epidermoid and 23 probable cases of dermoid tumor. Of the epidermoids, half were intramedullary and half extramedullary. The dermoids were more often extramedullary, and occasionally extradural. Preoperative diagnosis of these tumors is not always possible, but the association of a cutaneous dimple or a discharging sinus in the middle of the back or the presence of spina bifida should suggest

a congenital tumor of this type. A history of sterile meningitis or acute transverse myelitis is not uncommon in cases of epidermoid tumor, the complication probably being produced by liberation of fatty acids, formed within the cyst, into the subarachnoid space. Septic meningitis or localized subdural abscess arising from spread of infection from an associated congenital pilonidal (dermal) sinus is occasionally observed with a dermoid tumor.

SHENKIN, Philadelphia.

PRESENT CONCEPT AND STATUS OF MEDULLARY CONTUSION. ADHERBAL TOLOSA, Rev. Assoc. paulista de med. **12**:301, 1938.

Tolosa reviews at length the opinions of other authors on indirect traumatic concussion of the spinal cord. He has encountered 2 cases; in 1 a bullet perforated a vertebra without touching the dura mater, and in the other concussion was secondary to fracture of a vertebra. In both cases death followed a condition diagnosed clinically as complete section of the spinal cord. In the first case autopsy revealed a medullary lesion produced by a vast hemorrhage, and in the other, a focus of pure myelomalacia without hemorrhage.

The author concludes that traumatic medullary concussion is exclusively a clinical state and depends on brusk transitory inhibition of the function of the region traumatized. It therefore possesses no histopathologic characteristics. Contusion may evolve as myelomalacia or as softening and sclerosis secondary to hematomyelia. Probably the difference between commotion and contusion is one of degree. The author advises against precipitous laminectomy in such cases.

BAILEY, Chicago.

Peripheral and Cranial Nerves

THE OCCURRENCE OF PERIPHERAL FACIAL PARALYSIS IN HYPERTENSIVE VASCULAR DISEASE. HAROLD R. MERWARTH, Ann. Int. Med. **17**:298 (Aug.) 1942.

In cases of malignant hypertension bleeding from small arterial twigs is common, the main pathologic changes being in the small arteries and arterioles. Reports of bleeding from small arterial vessels of slightly greater caliber within the facial canal should not meet with skepticism, since there is adequate postmortem proof of such occurrence.

Twenty-four cases were studied in which paralysis of the facial nerve was associated with hypertensive vascular disease. In 16 of these, in which the ages ranged from 10 to 73 years, a certain constancy of onset of the paralysis warrants setting them apart on the etiologic basis of hemorrhagic compression within the aqueduct of the facial nerve. In all cases the onset of paralysis was sudden. In no case was there preauricular or postauricular pain or a perverted sensation of taste. When these symptoms precede the onset of paralysis and are severe, the paralysis cannot be considered to be caused by hemorrhage.

PRICE, Philadelphia.

GUILLAIN-BARRÉ SYNDROME: AN EARLY DIAGNOSIS. DONALD SHASKAN, J. Nerv. & Ment. Dis. **97**:280 (March) 1943.

Shaskan reports a case of the Guillain-Barré syndrome in which the diagnosis and studies of the blood and spinal fluid were made within five days of onset of the disease. The results of an attempt to isolate a virus from the spinal fluid were inconclusive; chemical and bacteriologic studies revealed nothing significant. A late collapse of respiration almost resulted in the patient's death. Because of this, too early discharge of patients with this condition is considered dangerous.

CHODOFF, Langley Field, Va.

THE CHEMICAL INHIBITION OF FIBER REGENERATION AND NEUROMA FORMATION IN PERIPHERAL NERVES. L. GUTTMANN and P. B. MEDAWAR, J. Neurol. & Psychiat. **5**:130 (July-Oct.) 1942.

Pain in amputation stumps is frequently associated with formation of neuromas. To relieve or prevent this, it is necessary to inhibit the regenerative growth of nerve fibers. Various surgical and chemical methods have been advocated. The authors experimented with chemical methods of inhibition by injecting a variety of fixatives and nonfixatives into the tibial nerve of the rabbit. They mention the following criteria for successful inhibitions: (1) decrease in the number of axons toward the periphery; (2) absence of adhesions, closure of the central stump and no escape of fibers; (3) no formation of neuroma; (4) no signs of unrestricted, free growth of fibers, and (5) absence of endoneurial connective tissue reaction. The authors find that as a class fixatives are superior to nonfixatives and that, of the former, a 20 to 40 per cent concentration of solution of formaldehyde or 1 per cent aqueous solution of gentian violet

gives the best results by preventing the development of end bulbs and adhesions for at least a year. Alcohol is relatively ineffective, while other fixatives occupy an intermediate position. The authors advocate the clinical application of these experimental results.

MALAMUD, Ann Arbor, Mich.

Treatment, Neurosurgery

THE EFFECT OF BENZEDRINE [AMPHETAMINE] SULFATE ON MIGRAINE. JACQUES S. GOTTLIEB, Am. J. M. Sc. **204**:553 (Oct.) 1942.

Gottlieb studied the effectiveness of amphetamine sulfate in treatment of 25 patients suffering from typical migraine. If the patients reported to the hospital during an attack, the drug was administered intravenously in doses of 3 to 20 mg. After their responses to intravenous medication were tested, patients were advised to take the drug orally in 10 to 40 mg. doses at the beginning of an attack. Eighteen received amphetamine sulfate intravenously from one to seven times for the relief of their attacks of migraine. Twelve (67 per cent) consistently obtained complete relief from their attacks in from seven to forty-five minutes. Most of the patients felt brighter and no longer fatigued. Medication administered orally was not as successful as when given intravenously. Eight patients (36 per cent) of the group obtained relief or had their paroxysms aborted in thirty to sixty minutes. Amphetamine sulfate was selected because it is a sympathomimetic compound with a prolonged action. It also decreases the amplitude of the pulsations of the cranial arteries.

MICHAELS, Boston.

THE EFFECT OF POTASSIUM THIOCYANATE ON THE OCCURRENCE OF MIGRAINE. DAVID E. ENGLE and CHARLES O. EVANSON, Am. J. M. Sc. **205**:697 (Nov.) 1942.

Engle and Evanson studied the effects of potassium thiocyanate on 13 patients with migraine. The average period of observation for each patient was eleven months. Patients who had attacks of migraine as frequently as three times per month, or who had coexisting hypertension, were instructed to take potassium thiocyanate to the amount of 6 grains (0.39 Gm.) daily for three days, and then 3 grains (0.19 Gm.) daily. Patients who had attacks of migraine less frequently than three times per month, and who could foretell the onset of an attack, were advised to take 6 grains of potassium thiocyanate when an attack seemed imminent. Twelve of the thirteen patients received substantial relief from migraine while taking the drug. The levels of thiocyanate in the blood which are effective against migraine are substantially lower than those generally considered to be most effective in the treatment of hypertension. The authors conclude that potassium thiocyanate properly administered is effective in reducing the frequency and severity of migraine headache.

MICHAELS, Boston.

EVALUATION OF CONTINUED THERAPY WITH PHENYTOIN SODIUM. LEON J. ROBINSON, Am. J. Psychiat. **99**:231 (Sept.) 1942.

Robinson studied the effects of administration of phenytoin sodium (dilantin) over long periods in 221 hospitalized patients with epilepsy. The patients had been treated with phenytoin sodium alone for as long as thirty to thiry-six months and with phenytoin sodium combined with phenobarbital for as long as thirty-eight or forty-one months. The results of therapy are as follows:

Drug	No. of Patients	Time, Mo.	Reduction of Seizures, %		
			Marked	Moderate	None
Phenobarbital	93	5-44	15	20.4	64.5
Phenytoin sodium	41	3-33	39	24.3	36.5
Phenytoin and phenobarbital	104	....	28.8	21.1	49.9

Robinson noted, further, that some patients who at first did not respond to anticonvulsive therapy did so after a time. The converse was likewise true. Salutary effects other than relief from seizures are pointed out. The average dose of phenytoin sodium was found to be 4½ grains (0.3 Gm.).

FORSTER, Boston.

RECENT CHANGES IN CONCEPT OF TREATMENT OF POLIOMYELITIS. A STEINDLER and others, Arch. Phys. Therapy **23**:321 (June) 1942.

The physiologist states that the passage of a muscle through its complete range of motion at frequent intervals enhances, rather than retards, recovery by stimulation of the venous circulation and lymphatic passages to the affected members. During the 1940-1941 epidemic of poliomyelitis in Iowa, Steindler and his associates studied 200 patients particularly from the standpoint of the development of contractures, which took place in approximately 25 per

cent. Severe and persistent extension contractures usually developed in patients who had been maintained in splints for some time. Evidence of circulatory disturbances, which result not only in impairment of circulation but in changes in the bone in the segmental area of the musculature involved, was most definite in patients with the most severe involvement of the surrounding musculature and contracture. As early as two or three months after the onset of poliomyelitis there was definite loosening of the ligamentous reenforcements of the severely involved joints, especially of the ankle and the shoulder. These changes occurred particularly in patients who had been wearing airplane splints and in whom a constant upward pressure on the shoulder joint was at work. From these observations it must be assumed not only that muscle is involved but that ligaments, bones and tendons play a part in the pathologic changes of anterior poliomyelitis. Extensive involvement of the musculature of the trunk was observed in more than half the patients. It was difficult to correlate the contractures of single groups of muscles because of the widespread and spotty nature of the paralysis. Since making these observations, the authors have tried to overcome the condition at its inception. They remove the splint for an hour twice a day and let the patient lie on his side with his hips and knees flexed. This is likely to loosen the contracture of the back, and there is no evidence that it produces contractures of the knee or hip. Miss Kenny has emphasized the fact that the patient must be reeducated to the use of the individual muscle; her suggestions for individual muscle training have been adopted, and certain departures from the old time orthodox treatment have been necessary. However, all fixation or immobilization should not be abandoned. Limbs that are unstable in their joints, whether or not they have recovered from the paralysis, must be supported. When walking or standing is resumed, apparatus for this support should not be used beyond the point at which static instability makes it necessary. When the soundness of the newer clinical observations on infantile paralysis is established, the application of common sense and of general biologic principles will free the treatment of poliomyelitis from orthodoxy and radicalism.

J. A. M. A.

TESTOSTERONE THERAPY OF MALE EUNUCHOIDS: SUBLINGUAL ADMINISTRATION OF TESTOSTERONE COMPOUNDS. H. LISSER, R. F. ESCAMILLA and L. E. CURTIS, J. Clin. Endocrinol. **2**:351 (June) 1942.

According to Lisser and his associates, 5 typical eunuchoids whose improvement had previously been successfully maintained by parenteral implantation and/or oral administration of testosterone continued in their improved status with sublingual use of testosterone. With only 1 of the 5 patients was less testosterone required when given sublingually than when given orally. The patients preferred swallowing tablets to dropping a solution under the tongue. Four hypogonadal patients with no previous testosterone therapy were subjectively and objectively benefited from the sublingual administration of testosterone compounds. Larger oral doses of methyl testosterone would have been required to accomplish equivalent results. When administration was sublingual, free testosterone was more effective than methyl testosterone or testosterone propionate. The androgen to be used was dissolved in propylene glycol so that 0.2 cc. contained 5 mg. of the testosterone compound.

J. A. M. A.

STUDIES ON THE USE OF REFRIGERATION THERAPY IN MENTAL DISEASE WITH REPORT OF SIXTEEN CASES. DOUGLAS GOLDMAN and MAYNARD MURRAY, J. Nerv. & Ment. Dis. **97**:152 (Feb.) 1943.

Goldman and Murray used refrigeration in treatment of 16 patients with mental disease, including schizophrenia and involutional and manic-depressive psychoses. After each patient had received a barbiturate preparation to induce initial anesthesia, he was placed in a cabinet, the temperature of which was kept between 30 and 60 F. Pentobarbital sodium proved to be the most useful anesthetic, not only in permitting the patient to be packed in ice without discomfort but in paralyzing the normal temperature-regulating mechanism. The body temperature was lowered to 88 or 90 F. by initial application of the ice and was maintained at 85 to 86 F. within the cabinet by keeping the latter at a level of 55 to 60 F. Intensive nursing care and oral and intravenous feeding were necessary during treatment. The return to normal temperature required three to eight hours. The state of consciousness during the treatments varied from complete loss to relative alertness. The physical changes noted during refrigeration were decreased tendon reflexes, diminished pupillary reflexes and abolition of coughing, micturition and defecation. Changes in the rate and rhythm of the heart and irregularities in respiration were usually indicative of trouble. Changes noted in the blood were: (1) a variable degree of hemoconcentration; (2) a tendency toward lowering of the sugar content; (3) nitrogen retention; (4) a lowered carbon dioxide–combining power, and

(5) a moderate drop in the chloride level. The chief complications were injuries to the skin from ice and infections of the respiratory tract, the latter being responsible for the 2 deaths which occurred during the treatment.

The results of treatment were disappointing. Except for transient, incomplete improvement in a few patients, no discernible results were noted. The authors have suspended the treatment in view of the considerable risk and the lack of benefit. CHODOFF, Langley Field, Va.

CEREBROSPINAL FEVER TREATED BY CHEMOTHERAPY. G. E. HARRIES, Brit. M. J. **2**:423 (Oct. 10) 1942.

Harries reports a series of 500 cases of cerebrospinal fever in which chemotherapy without intrathecal injection of serum was employed. The gross mortality rate was 8.6 per cent. When patients who died within the first twenty-four hours after admission were excluded, the mortality rate was 4.8 per cent. More males were affected than females. Most of the patients with this disease were between the ages of 15 and 25.

Harries proposes the following classification of cerebrospinal fever: meningococcic septicemic type, meningitic type and encephalitic type. Of particular diagnostic value in recognition of this condition are nuchal rigidity, purpuric eruptions, herpes, absence of photophobia and, in infants, a depressed fontanel. Sulfapyridine (2-[paraaminobenzenesulfonamido]-pyridine) was given by mouth to 471 patients and sulfathiazole (2-[paraaminobenzenesulfonamido]-thiazole) to the remaining 29 patients. Harries observed that sulfathiazole appeared to be as effective as sulfapyridine in promoting recovery and was less likely to produce nausea and vomiting. No patient was considered out of danger until the sugar content of the cerebrospinal fluid had returned to normal. For comatose patients tablets were crushed and given in nasal feedings. To patients who were severely ill the sodium salt of sulfapyridine was given intravenously. Fluids were forced in all cases. In patients with the acute fulminating form desoxycorticosterone acetate was given intramuscularly and 30 to 60 cc. of meningococcus antitoxin was administered intravenously. To all patients dextrose was given freely and a little table salt was added to the diet. Of the strains of meningococci cultured, 93 per cent belonged to group 1.

ECHOLS, New Orleans.

TREATMENT OF SHOCK BY DIRECT ACTION OF THE VEGETATIVE NERVOUS CENTERS. LENA C. STERN, Brit. M. J. **2**:538 (Nov. 7) 1942.

On the basis of experimental study, Stern advocates injection of potassium phosphate into the cisterna magna in the treatment of the last phase of traumatic shock. In this phase there are a fall in tone of the sympathetic and a rise in tone of the parasympathetic nervous system. The potassium phosphate diffuses through the intraventricular fluid and acts directly on the vegetative nervous centers to increase sympathetic and inhibit parasympathetic activity. The usual methods of combating shock by the injection of chemicals into the circulation are generally ineffective because the hematoencephalitic barrier prevents them from reaching the vegetative centers of the brain. The dose of the shock remedy advocated is 1 cc. of a solution of potassium phosphate in a concentration of ⅙ gram molecule with a p_H of 7.6. ECHOLS, New Orleans.

PHYSICAL TREATMENT OF ACUTE WAR NEUROSES. W. SARGANT, Brit. M. J. **2**:574 (Nov. 14) 1942.

Physical methods of treatment aid in shortening the period of total disability in many cases of acute war neuroses. The aim of physical treatment is "to bolster up the constitution so that unavoidable stresses are better tolerated by the individual." Heavy sedation, given as early as possible, is most beneficial in management of the acute panic state. When the neurotic symptoms persist for a week or longer, the patient should be hospitalized and continuous sleep induced. This treatment consists of the administration of a sedative drug in adjusted doses so that sleep is neither too light nor too deep and twenty hours of sleep a day are procured for a period of seven to ten days. During this time the patient receives three to four meals a day. To patients with a more chronic condition a modified form of insulin therapy should be given in a base hospital. By this treatment the patient is rapidly restored to some degree of working capacity, although he rarely can return to the full stresses that precipitated his illness. Convulsion therapy is recommended for the patient with a good previous personality and a genuine, severe depression. This treatment produces rapid improvement in about 75 per cent of patients. Sargant stresses the importance of the use of physical treatment in conjunction with other established methods, both psychotherapeutic and environmental, for patients with acute war neuroses. ECHOLS, New Orleans.

THE TREATMENT OF CEREBRAL CONTUSION. L. ROGERS, Brit. M. J. **1**:151 (Feb. 6) 1943.

Rogers calls attention to a method of treatment of cerebral contusion following "closed" injuries to the head which he states is theoretically, experimentally and clinically sound, and which consistently results in recovery without complications. He points out that the brain reacts to severe injury by attempting to increase its volume and that this expansion is limited by the meninges, the cerebrospinal fluid and the skull. Excessive swelling of the injured brain results in ischemia and necrosis. To provide room for expansion of the brain Rogers advocates removal of cerebrospinal fluid by dehydration measures. Dehydration is produced by the slow and gentle administration of retention enemas of 6 ounces (177 cc.) of a 30 per cent solution of magnesium sulfate in water every six hours; the fluid intake by mouth is restricted. The direct removal of cerebrospinal fluid by repeated lumbar puncture is not discussed.

The method has been used in the treatment of 550 patients with head injuries. Of these, 25 died, the majority soon after admission. There was a conspicuous absence of immediate and late complications. Not one of the 525 remaining patients required readmission for a "postconcussional" state or for any other complication.

ECHOLS, New Orleans.

EXPERIENCES IN THE TREATMENT OF DEPRESSIVE STATES BY ELECTRICALLY INDUCED CONVULSIONS. O. W. S. FITZGERALD, J. Ment. Sc. **89**:73 (Jan.) 1943.

Fitzgerald treated 150 patients with psychotic depressions, with the following results: (1) 117 patients (78 per cent) were discharged as recovered and continued in their home environment; (2) 6 patients (4 per cent) were discharged as improved; (3) 15 patients (10 per cent) remained in the hospital, and (4) 12 patients (8 per cent) were discharged but had a relapse and were readmitted to the hospital.

The average number of convulsions per patient was seventeen, regardless of the patient's age or the duration of the illness. The chances for recovery were unaffected by the duration of the illness up to the limit of three years, after which they diminished.

A six month period of observation by a social worker shows that 63 of the 85 patients discharged were known to be normal and usefully employed; 5 were unable to adjust; 9 were readmitted to hospital, and the condition of the rest could not be adequately evaluated.

The author suggests convulsions be given every day for a total of seven or eight treatments in order to make certain the patient is beyond the restless and agitated state.

M. M. PEARSON, Philadelphia.

CATAMNESIS OF PATIENTS WITH DEMENTIA PRAECOX SUBMITTED TO INSULIN THERAPY. A. P. QUARANTA, Rev. argent. de neurol. y psiquiat. **6**:109 (June) 1941.

In 1937 Quaranta resorted to insulin therapy in 41 cases of dementia praecox of different clinical forms and periods of duration. The duration was six months or less in 16 cases, one year or less in 12 cases and more than a year and a half in 17 cases. There were 17 cases of complete remission in the whole group, which corresponded to 10 out of 16 cases in the first group, 3 out of 12 in the second group and 4 out of 17 in the third group. Patients with a complete remission were observed for four years, by the end of which, in 1941, the remission lasted in 10 patients. Three patients had recurrences and are again under neuropsychiatric care. Four had recurrences but carried on a life which was compatible with their stay at home. All the 10 patients with permanent remissions were in good physical and mental condition, and were able to work. The author advises application of insulin therapy in cases of dementia praecox. The earlier the administration of the therapy, the better and more certain the results.

J. A. M. A.

TREATMENT OF CEREBROSPINAL SYPHILIS. J. MADSEN, Ugesk. f. læger **103**:1419 (Nov. 6) 1941.

Madsen says that lumbar puncture should be made in all cases of syphilis at the end of the septicemic period, or as a rule from three to six years after the infection. Normal spinal fluid in the latent period seems to exclude the later occurrence of neurosyphilis. If changes in the spinal fluid are found in this period, antisyphilitic treatment is justifiable, but if the spinal fluid does not become normal in the course of several months malaria treatment should be instituted. If signs of cerebrospinal syphilis are already present, for example, the Argyll Robertson symptom, a normal spinal fluid does not testify against an active inflammatory process in the nervous system, and in the author's opinion malaria treatment is indicated. A negative Wassermann reaction does not exclude cerebrospinal syphilis. If, without demonstrable cause, neurasthenic symptoms appear in a previously well

man in his prime, the possibility of beginning dementia paralytica is always to be borne in mind. On the diagnosis of such a condition, malaria treatment is called for as soon as possible, as the duration of the favorable period for treatment is a matter of weeks, rather than months. Malaria treatment is regarded as the most effective therapy of dementia paralytica. The author reports 4 cases in which such therapy was used. J. A. M. A.

TREATMENT OF CEREBROSPINAL SYPHILIS. E. LOMHOLT, Ugesk. f. læger **103**:1423 (Nov. 6) 1941.

Lomholt's view is that all forms of recent syphilis in the primary-secondary stage should be given powerful intermittent combined antisyphilitic and malaria treatment. In cases of acute syphilitic meningitis the reaction to the treatment is excellent, and the changes in the spinal fluid in the secondary stage usually quickly yield to the therapy. Until proof is available that powerful antisyphilitic treatment can prevent the later occurrence of neurosyphilis, the author considers this hypothesis as correct. To date, the few small series of cases in which therapy was adequate seem to confirm the hypothesis, he says, and practically all syphilologists of consequence agree that dementia paralytica or tabes is rarely seen in a patient who has had a fully effective treatment of syphilis according to the present day standard. For latent syphilis, with changes in the spinal fluid, in which the age of the infection is often unknown, he recommends immediate malaria treatment. To what extent such therapy can prevent the occurrence of tabes and paralysis is not certain, because no materials have been observed sufficiently long, but he has not seen any case of tabes or dementia paralytica after malaria treatment of syphilis in the latent stage. J. A. M. A.

Experimental Pathology

SPINAL INJURIES IN SHOCK AND EPILEPTIC CONVULSIONS. JOSEPH E. BARRETT, JAMES B. FUNKHOUSER and W. ALLEN BARKER, Am. J. Psychiat. **99**:387 (Nov.) 1942.

Barrett, Funkhouser and Barker studied four groups of 20 patients each, consisting of controls who did not have induced convulsions, metrazol-treated patients, electric shock–treated patients and epileptic patients. A flat lateral roentgenogram was made of the dorsal portion of the spine of each patient. No fractures occurred in the control group. A total of 5 fractures of the dorsal vertebrae occurred in the electric shock–treated group, 20 in the metrazol-treated group and 17 in the group of epileptic patients. The authors concluded that the fractures in the last group were indistinguishable in type and location from the fractures of the vertebrae in shock-treated patients. FORSTER, Philadelphia.

Encephalography, Ventriculography, Roentgenography

THE LOCALIZING VALUE OF THE CLINICAL, ELECTROENCEPHALOGRAPHIC, AND PNEUMOENCEPHALOGRAPHIC FINDINGS IN EPILEPSY. HENDRIKUS SJAARDEMA and MARK ALBERT GLASER, Am. J. M. Sc. **204**:703 (Nov.) 1942.

Sjaardema and Glaser compare the relative values of the clinical study, the electroencephalogram and the pneumoencephalogram for the localization of focal cerebral lesions in convulsive disorders in 52 patients. Twenty-four (46.2 per cent) were classified as having idiopathic epilepsy. Twenty-eight patients (53.8 per cent) of the entire series had symptomatic epilepsy. Of the entire group of 52 patients, 32 (61.5 per cent) had electroencephalographic seizure patterns. Sixteen patients showed differences in the alpha rhythms in the two occipital areas. In 33 patients delta and seizure waves originated in a circumscribed area of the brain. For 8 patients, or 15.4 per cent, the pneumoencephalogram was normal, while for 44 (84.6 per cent) some abnormality was noted. Ventricular shift was present in each of 9 patients (17.3 per cent). In all 9 patients the electroencephalogram accurately localized the side of the lesion. Of the series, the electroencephalogram localized the lesion in 33 patients (63.3 per cent), the clinical findings in 31 patients (59.3 per cent) and the air studies in 9 patients (17.2 per cent).

In 10 of the 31 patients with clinical focal epilepsy, the electroencephalogram and the clinical signs localized the lesion in the same lobe. In 7 of these 10 patients the pneumoencephalogram also localized the lesion in the same lobe. Of 24 patients with idiopathic epilepsy, the pneumoencephalogram revealed unequal ventricles in 16. In 6 patients (88 per cent) both the electroencephalogram and the clinical findings accurately localized the lesion. MICHAELS, Boston.

EPIDURAL CONTRAST INVESTIGATION OF LUMBOSACRAL CANAL IN PROLAPSE OF THE DISK. F. KNUTSSON, Acta radiol. **22**:694 (Dec. 3) 1941.

In about 20 cases in which clinical signs suggested protrusion of a vertebral disk, Knutsson carried out roentgenologic studies with epidural injection of perabrodil (same as skiadon). Ten cubic centimeters of a 1 per cent solution of procaine hydrochloride is injected and is followed by 20 cc. of 35 per cent perabrodil. A protrusion big enough to cause occlusion of the epidural space, with complete obstruction, or a protrusion occupying the greater part of the cross section and thus causing a defect in the contrast shadow can be discovered. Smaller protrusions may not be discovered. J. A. M. A.

Society Transactions

BOSTON SOCIETY OF PSYCHIATRY AND NEUROLOGY

WILLIAM G. LENNOX, M.D., *Presiding*

Regular Meeting, May 18, 1943

Neurosurgical Experience in Egypt and Libya.

MAJOR PETER B. ASCROFT, Royal Air Medical Corps.

The methods of treatment of missile wounds of the head have been gradually evolved as the result of nearly two years' experience in the Middle East. In a war of movement segregation of different types of cases is impossible in forward areas. At the base, when casualties are heavy, specialized units cannot hope to deal with more than a fraction of the cases. The military surgeon must be prepared to deal with wounds of all kinds. The functions of specialized units should be to deal with particularly difficult cases, to study intensively special kinds of injury and to make their results known.

The accompanying table shows the fate of 516 patients wounded in battle by missiles who came under the care of a mobile neurosurgical unit attached to a general hospital at the base. Patients arrived at intervals of from a few hours to more than a week after injury. About three fifths of the men had undergone operation while in forward areas; one-fourth underwent primary operation after reaching the base, and one-eighth were not operated on at all. All patients were kept under observation until they were fit for duty or, if unfit, until they were well enough to be evacuated from the command (seldom less than sixty days after injury). The unit worked for a time in forward areas, thus gaining first hand experience with battle casualties within a few hours of injury and under the somewhat difficult conditions prevailing in the open desert near the fighting zone.

Data on Severity of Injury, Mortality Rate and Disposal of Men with Head Wounds

	Mortality for Whole Series			Disposal of Recovered Patients *			
Severity of Injury	Number of Patients	Number of Deaths	Mortality, Percentage	Number of Patients	Men Invalided on Account of Head Wound †	Men Returned to Duty	
						Number	Percentage
Scalp wound only	85	0	0	80	1	76	95
Fracture of skull, dura intact	139	2	1.5	130	10	110	85
Dura pierced	292	44	15	226	93	124	55
Total	516	46	9	436	104	310	71

* Data were not available for 34 patients.
† Twenty-two patients whose head wounds did not incapacitate them for duty were unfit because of other wounds.

Head wounds which are not immediately fatal are less lethal and crippling than is popularly believed (table). The proportion of men who returned to duty, even after severe penetrating injuries, was much higher than was anticipated.

The great lesson of this war is that treatment of battle casualties depends as much on local conditions as on the nature of the wound. Today a fixed line of battle is the exception—conditions vary from day to day, and even from hour to hour—and the physician, no less than the fighting man, must be prepared without notice to alter his orthodox plan of campaign.

The general principles of treatment of all wounds, chief of which is early excision for prevention of sepsis, apply to injuries of the head no less than to wounds of other parts. There are, however, certain peculiarities of structure and function of the brain and its coverings which influence the behavior of head wounds and their treatment.

1. The scalp is richly supplied with blood; it has considerable resistance to infection and heals well.

2. Spreading osteomyelitis of the skull is rare (there was no instance in this series of more than 400 men with compound fracture).

3. The intact dura is a powerful barrier to the spread of infection, and the meninges as a whole have considerable power to localize infection.

4. The tissue of the brain resists infection well, provided the products of trauma and inflammation are not allowed to accumulate under pressure.

5. Continued exposure of the brain in an open wound is always harmful and is always associated with some degree of infection. It follows that some delay before operation is less harmful than might be supposed from experience with wounds elsewhere, since sepsis is seldom established soon, and that closure of the wound is highly desirable as a means of protection of the exposed brain and is often successful in acceleration of healing.

6. Organic damage to the brain is irreparable, and even the gentlest surgical manipulations are damaging in some degree.

7. Surgical manipulations within the skull cannot be carried out effectively without preliminary roentgenograms and special apparatus, especially an efficient mechanical sucker.

8. "Every scalp wound, no matter how trifling, is a potential penetrating wound of the skull" (Cushing, 1918).

DISCUSSION

DR. J. M. FAULKNER: Major Ascroft has reported the experience of the Eighth Army with regard to head injuries and has given conclusive evidence that it is preferable to wait until the men can be taken back where the proper facilities for treatment are available. He did not state what those facilities are. There are two: first a suction machine and, second, an apparatus for diathermy. The mobile unit to which I was attached had both, and they enabled Major Ascroft to get the results he did. Others who have been in the Middle

East have told me, and I think Major Ascroft will agree, that if the unit can take only one, it is preferable to have the suction apparatus, for with it the blood clots on the brain caused by the missile can be removed.

Major Ascroft has achieved results in the treatment of gunshot wounds of the brain that have surpassed anything before attained. His treatment of abscess was striking. He did not discuss that; I wish he had. His recovery rate of 75 per cent is much higher than the usual rate of 50 per cent.

DR. GILBERT HORRAX: I shall not discuss this paper, but I wish to thank Major Ascroft and Mr. Jefferson for coming to Boston to speak before this society on subjects in which we as neurosurgeons are so much interested.

I could not but contrast the situations as they pertain to the desert and those in Flanders in World War I. I am sure, as Dr. Faulkner stated, that the strong suction apparatus is one of the chief factors in the reduction of the mortality rate for gunshot wounds of the brain in this war. Obviously, sulfonamide compounds have played a part too, and I wish Major Ascroft had said how he used these — whether systemically or locally. All measures, however—suction, diathermy and sulfonamide compounds—as well as the terrain, must have been factors. The desert is relatively clean and exposed to the sunlight a great deal of the time, whereas in Flanders the field was a sea of mud. Men would fall and come in with their wounds oozing with mud.

Twenty-five years ago it was found that wounds cared for at the base hospital did worse than those cared for in forward areas, just because there were no sulfonamide drugs and adequate suction was not available. Surgeons did learn that it was extremely important to remove fragments of bone and other debris, rather than the metal foreign bodies themselves.

Major Ascroft has given a most interesting paper.

DR. DONALD MUNRO: Something should be said from the point of view of the scientific worth of this paper. Only those who have to do with problems of compound fracture of the skull can appreciate what a low mortality rate Major Ascroft has presented as a result of the treatment carried out by him and his co-workers. The mortality rate of 9 per cent following major compound fracture of the skull, even if the fracture is not complicated by fragments of missiles in the brain, is unknown in civilian practice, at least in this country. It is worth one's while to take notice of this method and to consider seriously its incorporation in private practice.

There were two points in the paper in which I was interested: First, Major Ascroft felt it necessary to comment on a case in which the man died of dehydration. It has long been my experience, also, that the greatest therapeutic need in cases of compound fracture of the skull is the administration of fluids shortly after receipt of the wound. This has proved to be our most usual advice in New England. I am delighted to have Major Ascroft's experience confirm ours. Second, in modern brain surgery under war conditions irrigation in treatment of compound fracture of the skull has been eliminated. This seems to me to be an extremely important factor and one of which surgeons in civilian practice should take note. It has indeed been a great privilege to hear the report of this extraordinary experience.

DR. WILLIAM J. MIXTER: I should like to add my word of thanks to Major Ascroft, as well as to Mr. Jefferson. We of this society are privileged in getting this information, and I am sure it will be of great value to surgeons of this country in the handling of such casualties. We owe our thanks not only to these men but to the British government, which allowed them to come.

MAJOR PETER ASCROFT, Royal Air Medical Corps: Professor Jefferson and I have looked forward to this trip ever since we heard that there might be an opportunity to come, and we shall always remember it with the greatest pleasure.

Work of the kind I have described is essentially team work, and I know the members of my unit will be extremely gratified when they hear the complimentary things that have been said about their methods in this country.

First, I must say that there is no collusion between Dr. Faulkner and myself. His comments were entirely spontaneous. I agree with him that the suction apparatus is the most important factor in the surgical treatment of head injuries.

Dr. Horrax asked about the use of sulfonamide compounds. For general administration, especially in cases of threatened meningitis, sulfadiazine is the most effective. Our policy was to give it in large doses. If the patient had any difficulty in swallowing or was very ill, so that his absorption was impaired, or if the spinal tract was impaired, we gave it intravenously in doses sufficient to produce a concentration of 15 mg. per hundred cubic centimeters of spinal fluid within twenty-four hours after development of the infection. For meningitis we gave enough to obtain a concentration of 15 mg. in twenty-four hours. We had some cases of meningitis due to the staphylococcus, and the patients recovered with that treatment. For local application we used sulfathiazole almost exclusively. That sounds like bad therapy to some people, for it is well known that application of sulfathiazole to the brain may cause fits. If the drug is spread around liberally after removal of a tumor, it will go into solution rapidly, as the spaces are wide open. On the other hand, in a gunshot wound the subarachnoid spaces are sealed off and the drug does not get into the cerebrospinal fluid in any considerable concentration, at least not in one of more than 3 or 4 mg. per hundred cubic centimeters. We observe one precaution: We never introduce the drug into a wound which communicates with a ventricle. There was infection in 6 of the 150 cases studied.

The suction apparatus, I am sure, has made a tremendous difference in our results. It provides the easiest method of cleaning out a wound of the brain and the simplest way of exposing and removing the little bits of bone which are so dangerous. The introduction of mechanical suction has to a great extent done away with the need for irrigation. The latter measure can be harmful in many cases, especially if a wound is open, for it is easy to blow dirt into the tract of the wound. We avoided irrigation of deep wounds.

Dr. Munro mentioned that the mortality in this series of cases of compound fracture of the skull was lower than that seen in civilian practice. This result is due not so much to us as to the difference in the type of wound. The average wound that occurs in peacetime is associated with a severe concussion effect. The usual injury due to a missile is local and much less severe, with less shaking up of the cerebral tissue.

Care of Head Injuries on a Large Scale. PROF. GEOFFREY JEFFERSON, Manchester, England.

Head injuries occurring both in the military and in the civilian population in Britain have been largely in the care of the special head centers created as an emergency measure for war purposes by the Ministry

of Health. This arrangement has on the whole proved satisfactory once the persons in charge realized the special aims of the services. It has permitted the British to be economical of their highly trained and specialized staffs, always too few in any country to allow of lavish provision for the fighting forces as well as for the essential workers in airplane and munition factories and for the families of the soldiers themselves. In ordinary civilian life concentration is all on the immediate, acute period; patients remain hospitalized for two or three weeks and travel the further steps of recuperation in home surroundings. Too often they build up exaggerated notions of the seriousness of a head injury and of their own injuries. Follow-up studies as a rule are made for scientific purposes and are best carried out as late as possible, for the determination of end results. Military considerations and the need to conserve manpower in factories have changed this objective. The large number of new beds available in Britain has made it possible for hospitals to retain patients longer than was the custom, and the patients have been carried through stages of rehabilitation under the direction of the clinician. Follow-up observations have been immediate, and contact with the patient has been maintained through the social worker (or Red Cross worker) or through regimental or other service medical officers. My colleagues and I have found it best to get the patients up early and not to permit their discharge until they feel well. This has led to the discovery that in the main they recover quickly, much more so than is commonly assumed and taught. I suspect that the good results which the advocates of routine dehydration have reported in their follow-up studies have gained overmuch credit because they have not been offset by the results of other treatment. Most surgeons, using more conservative methods, have not inquired how their patients have done. It is one of the curiosities of medicine that whenever surgeons gather to discuss head injuries they tend to fall into argument over the worst cases. They forget that the great majority of head injuries are mild; they would arrive at a more balanced judgment if they spent more time thinking about the lesser wounds as well. Furthermore, the surgeon's and the neuropsychiatrist's most vivid recollections of head injuries derive from the high grade neurotic patient and the litiginous patient. It is small wonder that the impression is deep, for these persons are powerful advocates of their subjective complaints. The mortality from bomb wounds of the head varied from 2.5 to 8 per cent, and the over-all mortality rate for persons with closed injuries to the head admitted to the special neurosurgical centers in Britain was about 5 per cent. The latter figure not only indicates that the treatment has been good; it is due particularly to the inclusion of relatively minor injuries which were cared for, as well as severe wounds. This factor has acted as a diluent to reduce the mortality, but its recognition gives a better idea of the real problem of head injuries. Patients are got out of bed as soon as they can sit up without discomfort, a point that may be reached in three or four days. We have abandoned the plan of keeping the patient flat; we treat him with the head high. We have also abandoned the rule of thumb practice of keeping the patient flat or bedfast for two, or even three, weeks. The results of the change have been revelatory. It is necessary to know whether cerebral laceration is present; so in all cases puncture is made as a diagnostic (not as a therapeutic) measure at some time during the first or the second day. In my own clinic, Dr. Bailley has been making differential punctures, cisternal and lumbar, and has found that the red cell count of the cisternal fluid is usually as high as, or higher than, that of the lumbar fluid. This seems to rule out sedimentation as the cause of the heavy staining of the lumbar fluid with blood which is sometimes seen. It is my belief that most of the blood in the spinal fluid comes from vessels that have easy access to the basal cisterns and that it is more often arterial than venous. Venous hemorrhage tends to be subdural rather than subarachnoid, though, to be sure, subdural bleeding may well have an arterial source, as all have seen.

Treatment in these centers has been conservative; in only one or two centers has dehydration been practiced. The post-traumatic syndrome is always neurotic when no blood is found in the cerebrospinal fluid. Even when blood is present, the patient is generally free from symptoms if he is kept from the contaminating influence of relatives, friends and neighbors. The neurosurgeon is accustomed to inflict severe, if locally controlled, injuries on the human brain, and nowadays he is not surprised if the patient is able to return to work without complaint, or in spite of mild complaints. Yet by some queer twist of reasoning, if a patient has sustained much less damage from a blow on the head, he is held entitled to compensation for disabilities. The key to many difficulties is the use of the psychiatrist, not as a therapeutic agent but as a diagnostic colleague. In England, a close association is springing up between the neurosurgeon and the psychiatrist which bids fair to be a fruitful partnership. In rehabilitation the chief emphasis should be on the entertainment of the patient's mind, rather than on the physics of his limbs. He must live according to a time table and be kept interested by some sort of occupation. Physical therapy, electric stimulation and diathermy are relatively unimportant adjuncts to treatment and must be kept in their proper place. The man must be treated as a thinking organism, not as an integrated nerve-muscle preparation. Above all, he must be prevented, as far as possible, from the very human failing of wishing to increase his self importance and self esteem by building up an idea of himself as one who has been through great danger and is lucky to be alive. I see the danger of not understanding real disability, but a carefully conducted program of rehabilitation that utilizes psychologic tests, weighs past performance and judges character should prevent grave injustice.

DISCUSSION

DR. JAMES C. WHITE: Two years ago it was my privilege to be sent by the United States Navy to England, after the heavy bombings, to see what was being done about head injuries. It was Mr. Jefferson who showed me the work he was doing and then came to London to point out to Dr. Penfield and me the things we should see.

I was impressed by the fact that men like Major Ascroft and Mr. William Henderson were sent to Egypt and that the men on the home front were organized so that they could look after the needs of the army, navy, air force and civilians. One man could do a tremendous amount of work in that way, and more economically than by having as here, for example, a neurosurgeon at Camp Devens, another at Camp Edwards and another here in Boston. In England one man would do all that work, and great benefit would be obtained from such experience.

In England there was a system of regional hospitals; for example, at Oxford there was a special center for men with head injuries, and there were other centers

for peripheral nerve injuries. This is a tremendous step in treatment; there is not that system here.

I should like to express my appreciation of this excellent paper.

PHILADELPHIA NEUROLOGICAL SOCIETY

GEORGE D. GAMMON, M.D., *Presiding*

Regular Meeting, May 28, 1943

Spinal Shock. DR. GRAYSON P. MCCOUCH, DR. JOSEPH HUGHES and DR. WINIFRED B. STEWART.

Spinal shock was defined as the more or less transient depression of reflexes following partial or complete transection of the neuraxis. After a brief survey of early inhibitory and circulatory theories of its production, the work of Sherrington, which replaced them with the concept of loss of facilitation from descending tracts, was reviewed in some detail, with passing reference to more recent work attempting to allocate the influence of vestibulospinal and corticospinal pathways. Van Harreveld's experiments with ischemia and the theory of inhibition which he evolved from them were briefly discussed.

The results of synchronous recording of intermediary cord potentials and reflexes concerned with the degree of block at interneurons and at motoneurons in different species were reviewed.

DISCUSSION

DR. HENRY WYCIS: I should like to discuss two points: First, Trendelenberg passed a small tube around the upper part of the spinal cord, through which he circulated ice water. He showed that the responses were reversible if the ice water was replaced with warm water. Second, Munk, in his classic experiments, studied two sets of dogs, both with transverse sections of the cord. One set he left entirely alone, while the other set he exercised, stimulated and examined daily. The dogs which were exercised showed a rapid return of spasticity, increased reflexes and hyperactivity, while the dogs which were not stimulated or exercised showed a return of spasticity, but only of a mild nature and after a prolonged period. He expressed the opinion that the lower motor neuron, being isolated from the influence of the higher centers, acquired a state of hyperexcitability and that this state was increased by afferent impulses. Perhaps these experiments of Munk help to explain some of the problems concerned with the bladder that arise after injections into the spinal cord.

DR. GRAYSON P. MCCOUCH: Without question, cerebral injury resulting in loss of reflexes should be classified as spinal shock. It is at the spinal level that withdrawal of facilitation from above produces its effect. The reason the effect does not last as long as that with transection of the cord is that a smaller fraction of the ascending pathways are cut off.

With regard to flaccidity versus spasticity, I can add little except a word as to the reason for the reflex picture. The degree of depression of each reflex is presumably determined by the percentage of its central drive removed by transection. After corticospinal lesions, reflex movements of the hand and foot suffer more than those of proximal segments of the limbs, for the same reason that loss of voluntary control follows a similar pattern—the heavy representation of digital movement in the motor cortex. Consequently, if after recovery of reflexes lost by ablation of area 4 the cord is transected, movement can be elicited earlier on the previously paretic side and the asymmetry will be greatest in the movements which suffered most from the cortical ablation. Since the monkey is an arboreal animal, the movements of grasping are highly developed on a purely spinal basis. Hence, in that animal they form the focal point of recovery after transection. Since the major site of shock in the monkey is in the anterior horn, crossed reflexes, like the ipsilateral ones, return first on the side of earliest recovery and in the units which respond most readily to ipsilateral stimuli. Thus, digital flexion, which is the first ipsilateral reflex, is likewise the first crossed response, and only after a week or more is it gradually replaced by crossed extension of the entire limb. One is tempted to speculate that the paralysis in extension, characteristic of incomplete transection, may be due to a less vulnerable position of the vestibulospinal tract than of the corticospinal path. It would be interesting to know whether a completely spinal man may not ultimately pass from a reflex balance yielding crossed flexion to one which favors crossed extension, the course following in terms of years that run by the monkey in a period of weeks or days and by the cat in one of hours or minutes.

With regard to the bladder: In the monkey, as in other laboratory animals, an automatic bladder may be established—in fact, more readily in the monkey than in the cat. I believe this is because the external sphincter muscle is less of an obstacle in the monkey than in the cat. What produces the dilated bladder, with no tone to speak of? I believe it may be explained by the presence of one, and only one, mechanism for inhibition of the external sphincter, that mechanism being the development of a strong stretch reflex in the detrusor muscle of the bladder. The bladder suffers from spinal shock; its stretch reflex is depressed, and consequently the external sphincter stays tight shut.

Laboratory animals recover to the point at which the bladder contracts again and expels urine in jets, with the clamping down of the sphincter and the resultant periodic interruption of micturition.

Analysis of Convulsive Movements by Slow Motion Pictures. DR. TEMPLE FAY.

The constant pattern of flexor-extensor movements seen in a major convulsive seizure following electric shock was analyzed synchronously in colored moving pictures at normal and at slow rates of speed. These characteristic movements strongly suggest swimming movements in a primitive amphibian pattern. When infants are placed on the abdomen, the flexor-extensor pattern is that of a swimming movement. Activities of the fish, tadpole, salamander, guinea pig and rat as they respond in a fluid environment were shown in slow motion picture. The same pattern of movement is exhibited by the fish, frog and salamander as that presented by the guinea pig, the rat and the human infant when placed on the abdomen and suspended under water so that free swimming activity can be noted. A special apparatus was devised to immerse rats and guinea pigs so that swimming movements could be noted with the animal in the normal swimming position after administration of doses of convulsive drugs sufficient to produce seizures. The observation indicated that the convulsive seizure is a release of a primitive amphibian swimming pattern rather than the result of cortical stimulation or irritation. It was suggested that the movements seen in a major convulsive seizure are in reality reactions of defense manifesting

a primitive attempt to readjust the mechanism to the free swimming state when normal relations in oxygen, water and salt become available. It is noted that these convulsive movements appear in forms above the amphibian level which have emerged from the free swimming state. A fit may be considered from the standpoint of its normal polygenetic origin rather than from the superstitious position of an evil disease or spirit. A fit may be a normal release phenomenon of a motor pattern at the amphibian level when higher cortical control centers are obliterated or temporarily removed.

DISCUSSION

Dr. D. J. McCarthy: I have little to add to what Dr. Fay has said. He stated that years ago the possibility of the epileptic attacks being a mass reflex phenomenon was suggested. The goldfish out of water, attempting to get back, may be exhibiting the effects of anoxemia of the cerebrum. The immediate cessation of the movements when it gets back into the water supports this view. It is unreasonable to assume that the fish thinks out these movements; they must be a protective reflex mechanism. Every one knows that a child swims before he walks. These pictures have shown that the typical epileptic convulsion consists of full flexion and extension movements. In the electrically induced convulsion rotary movements follow the anatomic structure of the cortex. This presentation has been extremely stimulating; furthermore, any one who thinks about epilepsy deserves encouragement.

Dr. Temple Fay: These moving pictures show that skilled movements and the acquired, educated movements in the human subject were absent. It is important to bear in mind that the type of movement in a convulsive seizure observed in an infant 2 days old is similar to that manifested by an adult, after years of motor training and specialized movements attributable to the motor cortex.

I agree that a full-fledged convulsion must be mediated through the motor cortex. However, I believe that the neurophysiologist should try to get away from the idea that the convulsion arises in the motor cortex. The convulsive seizure seems to me a spontaneous pattern manifested when a certain amount of cortical influence has been withdrawn. It is therefore, in my opinion, not a stimulation but a release phenomenon.

I differ with Dr. McCouch in the emphasis he places on the motor cortex in the convulsive attacks. One can get representative convulsions from the midbrain after the cortex has been removed. In fact, even when the cerebral peduncles have been sectioned, a form of "spinal epilepsy" arises which in pattern is not far removed from that observed in the full-blown attack. One should encourage the idea that the fit is a normal release phenomenon rather than foster the old concept that the cortex is the place of origin of the convulsion.

Book Reviews

Behavior and Neurosis. By Jules H. Masserman, M.D. Price, $3. Pp. 269. Chicago: University of Chicago Press, 1943.

The author's aim is to describe a series of experimental studies of animal behavior, in the belief that these studies contribute materially to the understanding of human behavior. He indicates the applicability of basic psychobiologic principles to psychoanalysis, clinical psychiatry and psychotherapy. The volume is divided into three parts: part 1, historical rationale and experimental results; part 2, a survey of relevant literature on dynamic psychology and experimental neurosis, and part 3, an introduction to the clinical applications of the data recorded.

The experimental data were acquired by a study of cats in a glass-enclosed cage equipped to provide incentives to behavior under controlled physical, spatial and temporal conditions. The cage was also equipped to provide sensory stimuli, and likewise it included means of frustrating adaptive behavior or of making the behavior conflictual. The incentive used was food served into the cage in cups mounted on a rotary wheel which opened into a feed box in the cage. The animal could get to the food by lifting the door of the feed box. Conflict-producing situations were produced by a blast of air from a fan directly across from a feed box, or by electrical shocks to the metal grill floor of the cage or to a smaller, movable escape platform. Bell, light and buzzer signals were provided.

In the first chapter the author formulates the following cardinal dynamic principles, derived from psychoanalysis: (1) Behavior is fundamentally motivated by needs of the organism; (2) behavior is related to an inner apperception of a total field situation, i. e., is imbued with a configuration of meaning to the percipient; (3) behavior is not always a simple and direct fulfilment of elementary needs, and (4) motivation may become conflictual because of the necessity of difficult adjustments to symbol. Masserman feels that the extension of these principles into the fields of general and comparative psychology has been neglected by psychoanalysis.

He then formulates these dynamic principles of behavior in psychobiologic terms as follows: (1) Behavior is fundamentally motivated by psychologic requirements of the organism; (2) the adaptive nature of behavior is related to the significance of the situation to the percipient; (3) behavior under partial frustration may take the form of symbolic expression and substitutive satisfactions, and (4) when meanings of the perceptive fields become confused or conflictual, behavior becomes inefficient, inappropriate, excessively symbolic and substitutive.

The author devotes a chapter to controverting effectively the recent tendency to undue stress on the role of the hypothalamus in the connotive and expressive aspects of behavior. He feels that one should assign to the hypothalamus its experimentally demonstrable role in reenforcing and coordinating the neural and hormonal mechanisms of connotive and emotional expression and reserve for more adequate proof the hypothesis that it is either the dynamic source or the seat of experience or affective states.

He then develops the thesis that "conditioned behavior" (i. e., adaptive response to significant symbols) can occur only in the experimental animal if the stimulus situation is made meaningful to the animal. "Behavioral" response should then become "neurotic" in character if the motivational connotations are made conflictual to a sufficient degree. This is in contrast to emotional-mimetic responses, such as sham rage, which are obtained by hypothalamic stimulation when there is no motivational connotation or meaning, and can therefore neither be conditioned nor made the basis for an experimental neurosis.

The author then proceeds to describe the training of cats to lift the lid of the box and procure food at a sound or a light signal. At first, frustrational effects caused by locking the box, etc., were produced, but no "neurotic" behavior developed. Then conflictual effects were produced by subjecting the cats to air blasts and/or electric grid shocks, and there developed in the animals an experimental neurosis characterized by a number of neurotic symptoms, such as chronic anxiety, phobic responses and compulsive behavior. The author was able to treat these experimental neuroses by such "therapeutic" technics as rest, diminution of intensity of the conflictual hunger drive and reassurance.

Part 2 of the book is a critical review of the experimental studies of behavior and of the neuroses. Part 3 develops the clinical and psychotherapeutic applications of the foregoing material. It should be noted that in this book of 269 pages of reading matter, only 12 pages are devoted to this portion, and they consist essentially of a restatement of the therapeutic technics developed in previous chapters of the book. In this connection the following statement is of interest: ". . . there are paramount differences between animal and human behavior which must be recognized in every discussion of the subject, . . . a cat has within its repertoire only a few and relatively primitive patterns even of normal behavior: its 'neurosis' can consist therefore only of correspondingly simple deviations. Although the patterns of these phenomena are highly suggestive of their persistent and elaborately symbolic counterparts in the human, nevertheless, no cat that I have observed has thus far had the

imagery to solve its anxiety by strutting, growling, or dressing like Mussolini in over reaction to feline feelings of frustration and inferiority."

In the introduction to the third part the author states that the previous sections have been devoted to a demonstration of the psychobiologic principles underlying the phenomena of "normal" and "abnormal" behavior in general, i. e., in both animals and man. He feels that the task of reviewing the application of these principles to psychiatry, psychoanalysis and clinical psychotherapy should have been reserved for a separate book. With this opinion the reviewer concurs.

Within the limits which he has set, the author has done an excellent job in attempting to integrate comparative psychologic, psychobiologic and psychoanalytic data. It should be remembered constantly that the author's endeavors are directed to explaining behavior and motivational conflicts in a cat, admittedly an animal of much simpler and more elementary modes of reactive adaptability than man. The book is highly recommended as a bold step toward a long-needed and much to be desired integration of what were once considered incompatible scientific doctrines.

The Psychiatric Novels of Oliver Wendell Holmes. Abridgement, Introduction and Annotations by Clarence P. Oberndorf, M.D., Clinical Professor of Psychiatry, Columbia University. Price $3. Pp. 268. New York: Columbia University Press, 1943.

In a recent address before the New York Academy of Medicine, Reginald Fitz said that Holmes was a man a hundred years ahead of his time. This was stated at a meeting celebrating the hundredth anniversary of Holmes's paper on the infectious nature of puerperal fever. In psychiatry he was perhaps not a century ahead of his time, but at least seventy years, for he wrote his three "medicated" novels in the latter part of his life ("Elsie Venner," 1859; "The Guardian Angel," 1867, and "A Mortal Antipathy," 1885). They were unsuccessful and were severely criticized; in fact, "Elsie Venner" is the only one that is a passably good story and has literary merit; the other two seem inept and amateurish as compared with his essays and scientific papers. The reason may be that Holmes was for once indirect and was writing about subjects which he knew would not be understood; as he put it, the subject matter "would have to be wrapped in some tissue of circumstances or would lose half its effectiveness." It has taken three quarters of a century for a commentator to see the merit of Holmes's books. We owe to Oberndorf much gratitude for the discovery and for the scholarly treatment given the subject. His abridgments make the novels more readable; his introduction gives a brilliant picture of Holmes, and his annotations explain to people not trained in psychiatry the importance of the text. To the psychiatrist the text needs little explanation; the clinical descriptions are masterly, and many theories are clearly stated which would now be called "freudian."

"The theme of *Elsie Venner* was a lifelong favorite of the author, namely that there is no such thing as total depravity. Because of his inherited tendencies no man can be held completely responsible for certain traits of character, certain deficiencies, mental quirks, or even criminal inclinations. The will therefore is never completely free. Later Holmes formulated this lack of complete control of our actions as being due to the continuous operation of unconscious impulses and thought."

"*The Guardian Angel* is psychiatrically by far the most significant of Holmes's three novels, as it introduces specifically many factors which are today considered of essential importance in the production of mental disorders. Among these may be mentioned such questions as the pernicious influence of austerity upon a child, the power and effect of unconscious forces, the elements entering into personality formation, and the role of faith and religion as curative agents."

"Particularly unexpected is the fine understanding of the nature of transference, often regarded as an entirely modern contribution, as a guide to the interpretation and treatment of psychiatric reactions. Furthermore, we come upon the concept of regeneration through rebirth, and finally, the rehabilitating and integrating effect of the liberation of repressed love impulses."

"*A Mortal Antipathy* is from a psychiatric standpoint the simplest and most direct of the novels. Perhaps it is oversimplified for it represents Maurice Kirkwood, the sufferer from a phobia, as perfectly normal except in respect to his fear of women due to a single infantile shock. It presents theories far in advance of that time concerning the structure of neuroses and the understanding and management of such cases. One may consider it as a summary of observation and theories with which Holmes had occupied himself over the last three decades of his life."

From the text of the three books, it is clear that Holmes believed in phobia arising from psychic trauma in infancy, in hysteria arising from emotional conflicts in a girl whose instincts (inherited reactions) and ideals were incompatible and in habitual invalidism arising from repressed jealousy, "a feeling which had hardly risen into the region of inwardly articulated thought but lay unshaped beneath all the syllabled trains of sleeping and waking consciousness." He also described projection and used the term in its current psychiatric sense; he spoke of "unconscious dramatization"; he considered it his task "to lay bare all the springs" of his heroine's action, i. e., psychic motivation. There is no doubt that Holmes had remarkable psychologic insight and could have initiated dynamic psychology in 1870 if the medical world had been ready to accept it.

The Techniques of Self-Help in Psychiatric After-Care. Developed by Recovery, Inc., the Association of Former Patients. By Abraham A. Low, M.D. Vol. I. Recovery's Self-Help Techniques: History and Description. Price, $1.25. Pp. 138. Vol. II. Group Psychotherapy. Price, $1.25. Pp. 88. Vol. III. Lectures to Relatives of Former Patients. Price, $1.25. Pp. 125. Chicago: Recovery, Inc., 1943.

These three books, sponsored by the Association of Former Mental Patients, give a comprehensive report of an imposing system of group technics evolved by the author. Dr. Low is the founder and president of the association and is associate psychiatrist at the Neuropsychiatric Institute of the University of Illinois.

The first volume consists of articles and items previously published in the bulletin of the association, and deals with the historical development of the association from the time of its foundation, in 1937, to 1943. The aim of the association has been to eradicate the stigma attached to mental disease, through various activities in the social, economic and legal spheres, directed and executed by the members themselves. These measures have included, in addition to social activities among its members, publication of a bulletin, to which members are encouraged to contribute, arrangement of public lectures and radio talks to enlist support for revision of the commitment laws of Illinois and operation of a labor exchange to find employment for former patients.

The second volume, as its subtitle indicates, is "a record of class interviews given to patients suffering from mental and nervous ailments." It consists of twelve interviews, divided into three parts. The first eleven are of the "single interview" type, in which the symptoms of one patient are discussed by the therapeutist in the presence of other patients. The twelfth is of the "multiple interview" type, in which the symptoms of one patient are discussed by several other patients under the guidance of the therapeutist. The method used by the author contains much of the repressive-inspirational factor, with little of the analytic. Intellectualization, that is, understanding and mastering the symptoms, and Dubois' technic of persuasion therapy are stressed. The first part of the book contains three interviews, which deal with topics of sensation under the headings: "Real Sensations and Fantastic Interpretations"; "Normal and Abnormal Interpretations," and "Sensations are Distressing but Not Dangerous." The second part contains eight interviews, in which are discussed various symptoms and mechanisms, such as "the vicious cycle of panic" and "adult versus infantile valuations." In the third part more difficult material, such as "intellectual versus emotional insight" and "will training and tenseness," is discussed. Throughout the book generous use is made of contrast formulations, as shown by the titles of the interviews cited.

The third volume consists of fifteen lectures selected from a series given by the author twice a month during a three-year period before an audience composed of relatives of patients of the Neuropsychiatric Institute of the University of Illinois. In the introduction, Low discusses the importance of the "domestic scene" to which the patient returns from the hospital, and which is often responsible for his relapse. The role of overprotection, which the patient resents, often leads to temperamental explosions. The first six lectures deal with general principles of constitution and environment and with standards of behavior, such as moral, legal, ethical, esthetic and conditional; the importance of the domestic trivia of everyday behavior is stressed. The author then discusses motives of behavior and classifies them as those of service and those of domination, types which give rise respectively to submissive and domineering dispositions or temperaments. The remaining lectures are devoted to temperamental deadlocks and their control. Insight and understanding of the working mechanism of temper, plus persistent practice in control of temper, are suggested as therapeutic means. In this book the author continues with contrast formulations, such as inclinations versus obligations, emotional balance versus intellectual instability and will to peace versus will to power.

In the opinion of the reviewer, the three books offer interesting material on another approach to the broad problem of psychiatric after-care of discharged patients.

Contemporary Psychopathology. Edited by Silvan S. Tompkins. Price, $5. Pp. 600, with index. Cambridge, Mass.: Harvard University Press, 1943.

The subtitle to this volume describes it as a source book, and the preface states that it is designed for courses in abnormal psychology. While the editor has thus defined the limitations within which he has chosen the material, it seems best for the purposes of this review to consider the book mainly from the point of view of its title, i. e., contemporary psychopathology, without the additional limitation described.

The volume is a collection of 45 papers gathered together from widely distributed current scientific periodical literature. That this material can be considered truly current is indicated by the fact that only 8 articles were published prior to 1939 and only 1 prior to 1933. The book is subdivided into four sections, as follows: (1) mental diseases in children; (2) psychoneuroses and psychosomatic medicine; (3) the schizophrenic psychoses, and (4) experimental psychopathology.

The first section, on mental diseases in children, consists of 7 articles and concerns itself with dynamic interpretative material on the developmental problems of infancy and childhood. No space is devoted to a discussion of psychoses in children, delinquency problems or other material which might be considered important to workers in this field.

In the second section, devoted to the psychoneuroses and psychosomatic medicine, there are 10 articles, 4 of which are concerned with the important consideration of the gastrointestinal tract as the seat of expression for psychosomatic disorders and 1 each with the respiratory and the cardiovascular system as the site of dysfunction. The remaining articles are given over to methods of investigation and treatment of some psychoneurotic disorders, including war neuroses. In this section one might ask for additional material on such disorders as arthritis and migraine.

The section on the schizophrenic psychoses consists of 13 articles, in which schizophrenia and schizophrenic processes are surveyed from the physiologic, the psychologic and the psychodynamic point of view. The articles on therapy cover insulin and metrazol shock, prefrontal lobotomy and modified and specialized analytic technics. The absence of material on electric shock is apparent.

The last section, devoted to experimental psychopathology, covers, as it must, a wide variety of subjects, including data on animal, as well as human, material. Frustration experiments, conditioned reflex studies, hypnotism, stress studies and topologic and vector psychology are discussed. One might ask for a more extended consideration of the use of thematic apperception technics in the study of the neuroses and psychoses.

The reviewer has considered the subdivisions in some detail and has noted possible additional data which might have been included in conformity with his announced intention of discussing the book for the most part from the point of view of its title, "Contemporary Psychopathology, a Source Book." However, as one reads along in this volume, one cannot help but be struck by the tremendously widened horizons of the psychiatric landscape. It becomes apparent how utterly impossible a comprehensive survey of psychopathologic phenomena really is. The material from certain contemporary trends in psychopathology and psychotherapy is chosen. In the words of the introduction, these trends are chiefly three: (1) the spread of psychoanalysis; (2) the emergence of psychosomatic medicine as a new discipline, and (3) the development of experimental procedures, suitable to the investigation of vital problems of human behavior.

With this decision on the part of the editor so to limit his material one can have no quarrel. He is rather to be congratulated on his guiding the reader so straight through the otherwise impenetrable jungle of accumulated psychologic literature. Aside from the obvious merit of this collection for use in courses in abnormal psychology, its place on the reading shelf of the literature-swamped psychologist, psychiatrist and psychoanalyst seems assured. The book is highly recommended.

Mind: Perception and Thought in Their Constructive Aspects. By Paul Schilder, M.D. Price, $5. Pp. xxi, plus 432. New York: Columbia University Press, 1942.

This is an exciting book—stimulating, arresting, irritating at times. It was virtually completed by Schilder before his untimely death, but shows evidence toward its end of slackening in the acuteness of reasoning that is present in the earlier parts. One would have enjoyed further discussion of the nature of consciousness and of psychic energy. As he indicates in his foreword, Schilder uses the principles gained in the investigation of the body image in an attempt to define the phenomena of perception and thought. He continues: "I extend the results and methods of modern psychology into a field which so far has not been studied from this point of view. As is every serious worker in this field, I am deeply influenced by Freud. However, guided by my own efforts and by my own material, I have developed my own ideas. Freud's work is an era in psychology. In order to utilize it fully, new, independent efforts are necessary."

Schilder's style is rather jerky. He advances one striking hypothesis after another, often with an assurance that is scarcely justified by the context, and the foundations for his theories must probably be sought in the teachings of his school of philosophy. Indeed, if this were the first book of the author's encountered, the reader would be confused and wonder why Schilder was so highly regarded as a medical philosopher. When the author states: "I have come to the general conclusion that the size and weight of objects, the distance and dimensions of space, speed, impact and motion, become more or less the immediate expression of the total libidinous situation," the reader is inclined to consider such a sweeping generalization to be no more than a reckless assertion founded on subjective interpretations of a feeling of awe in contemplation of the cosmos. There is, furthermore, a vagueness that is unsettling. "Changes" in the vegetative system, "changes" in consciousness, "changes" in tone and in reaction movements, "changes" in the postural model of the body—all these are mentioned, and all on the same page, without the author's describing what the changes are. No doubt he has in mind what such changes are, and in many other instances he describes them with greater precision. One must ask, however, whether this is the power of a great intellect. Perhaps facility in the expression of ideas makes them appear large precisely because they are vague.

Schilder is at his best in dealing with the ideas of others, usually in critical fashion. He thoroughly demolishes the conditioned "reflex" theory of Pavlov and proves clearly that the animal subject is responding to a total situation. He is equally critical of some of the psychoanalytic interpretations that have been advanced by followers of Freud. He approves the tenets of the gestalt school of psychology and devotes considerable space to elaborations of this theory. Perhaps his most enduring contribution is on the subject of thinking: "I am inclined to define thinking as an act directed towards objects, the performance of which is intercepted by acts directed towards other objects. This interference appears in pictures. It is characteristic of the fertile act of thinking that it reaches its goal, insight into its object relation, in spite of the breakage." He pays great attention to thought mechanisms, and yet relatively little to the affective aspects of self contemplation and to alterations of attitudes toward the self that occur constantly, and more or less rhythmically, in the normal and in the abnormal state. While highly symbolic expressions are employed, the whole discussion seems often too intellectualized to correspond with experience. Schilder is inclined to join together the types of thinking found in the primitive, the child and the schizophrenic personality, but with nothing to give precision to this dubious doctrine. On the whole, one is inclined to wonder how much of this delving into the region of the mind will survive a half-century of further penetration. Part of Freud's greatness is attributable to the simplicity of his concepts. Schilder's cannot be measured by the same yardstick.

Lincoln—Douglas: The Weather as Destiny. By William F. Petersen. Price, $3. Pp. viii, plus 305. Springfield, Ill.: Charles C Thomas, Publisher, 1943.

Lincoln was 6 feet 4 inches (193 cm.) or over; Douglas was under 5 feet 3 inches (160 cm.) and broad in proportion. Lincoln was conceived in cold, rainy weather; Douglas, in midsummer. Lincoln was close to the soil from infancy; Douglas was raised in comparative luxury. Both of them came on the scene in southern Illinois, where mortality rates for tuberculosis are still high. Petersen contrasts the careers of these two striking personalities, with the background made up of cosmic forces that pass almost unnoticed by most persons. Lincoln, in youth robust and powerful, became gaunt, and almost frail, with early manhood and was subject to periodic depressions. However, he endured a political campaign that left his opponent, "a steam engine in britches," completely worn out, and was entering into the fulness of mature vigor when Douglas wore out and died, at the age of 48.

While Lincoln and Douglas are the principal actors in this drama, Mary Todd, with her pyknic physique and her paranoid psychosis, also attracts a share of the author's attention and sympathy. These are the players, but the play is about all men and their destiny as interpreted in the light of cosmology. As the author states:

"The tragedy of our three chief actors—Lincoln and Douglas and Mary Todd ended long ago; the story, however, is valid for the rest of us. All three were Prometheans—who dared; but all had to bow to the

laws of the Universe. Forever and ever are we bound to the earth no matter how far we seem removed. Our clay feet must march to the deadly drum beat of the Cosmic Master, if not, we merely perish the sooner. With age our clay feet tire, and some time we will miss a beat. But the stream of youthful protoplasm will march on while we, who are dust, blow away into the evening."

It must not be supposed that all parts of the book are equally elegiac, but the author, in his interpretations of events in terms of weather and the cosmos, lifts his eyes beyond the usual horizon of the individual and calls on Hippocrates to witness that besides man himself there are airs, waters and places. The book reads well beside a wood fire, with the patter of rain and the sough of the wind outside. Man tends to forget about the weather when, in this machine age, he has finally succeeded in doing something about it.

Neurologia ocular. By E. Adroqué. Pp. 882, plus index. Buenos Aires: El Ateneo, 1942.

This is the best comprehensive treatise on the neurology of the eye since the publication of Wilbrand and Saenger's "Handbuch." It is a magnificent volume, clearly written, obviously on a basis of wide personal experience, and richly illustrated. There are excellent chapters, with clear diagrams, on the coordination of ocular movements and their disturbances. The section on binocular vision is notable for its clarity and its scholarly approach.

The chapters on the pathology of the eye and the optic nerve are exhaustive. They are illustrated with actual photographs of the fundus, which are convincing but not always as clear in detail as drawings. The visual fields which are presented are for the most part from cases in the author's own experience; they are invariably taken with several disks by the Walker technic. Particularly outstanding are the chapters on tumors of the chiasmal region. The medical disorders of the eye are also covered in detail.

The value of the work would have been much enhanced by a bibliography. The presswork is excellent.

Women in Wartime. Price $0.35. No paging. Chicago: Institute for Psychoanalysis, 1943.

"Women in Wartime" is a pamphlet published by the Institute for Psychoanalysis, in Chicago. No authors are named.

An attempt is made to outline some of the emotional adjustments of women in their everyday life in wartime; as the article states, the discussion is directed to people who work with women and must understand their needs. The pamphlet is divided into six chapters, entitled, "Women in Wartime," "Changes in the Family," "Separation," "Women at Work," "Rationing" and "At Home and Abroad."

The material is well organized but contains little that has not been frequently discussed. Taken as a whole, the content seems directed to the laity rather than to the medical profession. Some psychologic interpretations are given, but for the most part they are superficial. One gets the impression that the material is selected for a general audience and that more profound interpretations, which would have been of interest to the psychiatrist, have been omitted.

The criticism may be made that frequently the extremes in reactions are given much prominence, whereas the more common and usual reactions are only mentioned.

The pamphlet can be recommended for a general understanding of some of the emotional reactions in women in wartime, and it is to be hoped that it may stimulate interest in further study.

Development in Adolescence. By Harold E. Jones. Price, $2. Pp. 161. New York: D. Appleton-Century Co., Inc., 1943.

The book is a report based on the record of 1 boy for a period of seven years, from 12 to 17 years of age. The boy is selected from a group of 80 children who were studied by the Adolescent Growth Study Institute of Child Welfare of the University of California. A mass of data about the boy is condensed into this rather brief summary. Instead of a presentation of the usual tables of averages for the group, a careful analysis of this individual and his relationship to his group is presented. The theme is that of a boy with many soicial handicaps and inferiorities who has a tremendous drive to succeed and with his first year at college has outwardly begun to achieve some success. Before his fifteenth year he was undersized but then had a rapid growth to normal stature. With this came a better adjustment. The difficulties the adolescent boy encounters because of physical inaptitude are clearly revealed. A vivid portrayal of the internal conflicts and the boy's attempts at counteracting his own handicaps is presented. The deviation in behavior that may occur within normal limits in adolescents, but with an eventual normal development, is demonstrated. The book is well worth reading. However, no dynamic interpretations are given. Much too little space is devoted to the influence of a demanding, exciting, dominating mother, who ruled not only the child but her husband. Also, the sexual problem of the adolescent boy is not mentioned, except in terms of social dancing.